UNIVERSITY OF BRISTOL.

THE ANNUAL REPORT

OF THE

Agricultural and Horticultural Research Station

(THE NATIONAL FRUIT AND CIDER INSTITUTE),

LONG ASHTON, BRISTOL,

1923.

BATH :

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INTRODUCTION.

In reviewing the work of the Institute during 1923, while there is considerable development in various directions to be recorded, the year has been noteworthy mainly as the first since the outbreak of the war to permit of the conduct of the work under relatively settled and stable conditions. The approximate amount of the grant available from the Ministry of Agriculture for the maintenance of the Station until 1927 has been provisionally decided and the programme of work correspondingly determined. Under these conditions steady all-round progress has been made. The younger fruit plantations established since 1918 are approaching the result-producing stage, definite headway is being made with investigations which have been in hand for some time, the work of the Station is becoming much more widely known, the number of visitors increases each year, and the applications received for advice and assistance have advanced in number in a striking degree.

During the year the greater part of the extensions referred to in the last Annual Report as provided for by a capital grant of £5,000 from the Ministry of Agriculture have been completed. These are recorded in the following paragraphs, which also deal with other matters of general interest which have occurred during the period under review.

Staff.—The vacancy in the post of Research Mycologist, referred to in last year's Report as resulting from Mr. S. P. Wiltshire's resignation to join the staff of the Imperial Bureau of Mycology, has been filled by the appointment of Mr. H. R. Briton-Jones, B.Sc., late Mycologist to the Egyptian Ministry of Agriculture. Mr. Briton-Jones started work at Long Ashton in March last. In addition to the researches in various diseases of fruit which he has begun and to some of which reference is made below, he has given considerable time to the advisory work in fungoid diseases of the agricultural and horticultural crops which has arisen in the Bristol Province during the year. It is expected that he will be able to devote the whole of his time to research in future, since the impending appointment of an Adviser for Mycology, for which sanction has now been received, will relieve him of any normal advisory work.

The transfer of Mr. A. H. Lees from the Advisory Staff to the Research Staff as Research Entomologist, mentioned in the last

Report as having been arranged, has now taken place. Mr. E. Ballard, B.A., late Entomologist to the Madras Government, has succeeded him as Adviser in Economic Entomology, having taken up his duties in January last.

The resignation of Mr. F. Summers was received on his appointment as Head of the Botanical Department of the Shirley Research Association on Cotton. His departure at the end of September left the post of Plant Physiologist vacant. Future arrangements with regard to this post are at present under consideration. Pending their settlement it will be left open.

Mr. S. S. Light, B.Sc., has during the year been engaged at Long Ashton on an investigation on the mosses, lichens and algae found on the bark of fruit trees, their removal with winter washes, and the effect of the latter upon hibernating insects and fungus spores. The cost of this work was met by a special grant awarded to him by the Ministry of Agriculture and Fisheries.

Miss Gilchrist, B.Sc., Lecturer in the Botanical Department of the University of Bristol, who has, as previously reported, been investigating the Myxosporium disease of apple trees, is now taking a year's course of study in the United States. It is hoped that she will be able to resume this research on her return next summer.

Miss Ridler, of the same Department, is continuing in conjunction with Mr. Lees her research on the comparative anatomy of healthy and reverted Black Currant plants.

In connection with the survey of soils in the fruit-growing districts of East Anglia and the West of England, begun by this Station last year in collaboration with the Cambridge University School of Agriculture, Mr. A. W. Ling, N.D.A., has been appointed research assistant to Mr. Wallace, who is undertaking the Long Ashton section of the work.

Mr. J. F. Ward, B.A., after completing his horticultural course at Cambridge University, is now engaged upon an investigation at Long Ashton on the character and development of the root systems of red and black currants.

Land and Plantations.—Reference was made in last year's Report to the preparations in hand for the establishment of additional fruit plantations for experimental work. Of the thirty acres of land taken over from Fenswood Farm since the beginning of 1921 approximately one-third was arable and the remainder pasture, the two fields of which that area is comprised adjoining and being separated from each other and the adjacent Paradise plot of cider bush trees by hedges. The latter have been grubbed, making one continuous stretch of land about thirty acres in extent. Shelter belts of trees are being planted on the south-western and north-western boundaries with additional windbreaks running north and south across the land, dividing it into three

sections of almost equal breadth. The pipe drainage of the whole area has been completed and the portion formerly under grass has been ploughed and prepared for preliminary cropping with agricultural crops before being planted with fruit. The remainder has now been planted, mainly with bush apples, with the exception of a section to be devoted to manurial experiments on strawberries, the plants required for which will be ready during the spring of 1924. The apple plots will be used chiefly for pruning and spraying experiments. Soft fruits—currants and raspberries—have been interplanted among the apples. An acre plot of loganberries has been also planted in the adjacent Paradise plot. A strip of grass land, about four acres in extent, on the south side of the railway, lying between it and the plantations established on the termination of the war, has been broken up and is now in preparation for fruit.

In the field mentioned in last year's Report as appropriated for the Willow trials, a plot of one acre has been prepared and planted with 80 varieties of willows for trial purposes. Allowing for the unfavourable character of the early summer, following so soon after planting, the willows generally have grown well and indicate that the land suitable for the work contemplated.

The development of the area on the south side of the railway—some 80 acres in all—has necessitated the erection of new farm buildings, (see next section), and the construction of a roadway half a mile in length to serve the new plantations. This work has been completed during the year. The land in question is crossed by two rights-of-way, diversion of the course of which was desirable to avoid awkward intersection of the experimental plots. The sanction of the Long Ashton Parish Council to the diversions having been secured, new paths have been made and fenced.

Buildings.—The considerable recent extensions of the fruit plantations have rendered the provision of additional farm buildings necessary. The new buildings which have been erected during the year include stabling, a packing shed and stores, an office for the fruit foreman, a mess-room and watchman's quarters. They are situated in a central position on the land which has been developed on the south side of the railway and, being adjacent to one of the railway bridges, are also in close touch with the older plantations on the opposite side of the line. A yard surrounding these buildings is being enclosed and metalled.

The increasing amount of experimental work which requires pot culture treatment has outgrown the capacity of the accommodation under glass hitherto available. During the year the latter has been extended by the erection of an orchard house for physiological experiments and an addition to the old lean-to greenhouse.

Plans for an insectory, a shelter for outdoor pot experiments, and an addition to the original orchard house have been prepared.

The recent and impending Staff increases have made a re-arrangement of laboratory accommodation essential. It has involved the division of the large room into two smaller laboratories and the conversion of a portion of the shedding adjoining the greenhouses into small laboratories for plant physiological work and the willow research. The loss of the large room in the laboratory building by the division just referred to has left the Station without accommodation for meetings and lectures, while the available shelf room in the library has now become inadequate for the annually increasing stock of literature. It is hoped that sufficient funds will be available to permit of the extension of the library to serve both requirements ; plans for this are now under consideration.

During the summer the cider house has been enlarged by the addition of a one-storey building about 55 feet square. It adjoins the existing press-room, which has been thrown into it, and has been constructed to permit of more extensive storage for cider fruit under cover, the removal of the mill from the old mill-room to a position adjoining the press and the provision of washing facilities for fruit prior to milling. The equipment of the cider house has also in other respects been improved and brought more up-to-date.

General.—The survey of soils in certain of the fruit-growing districts of East Anglia and the West of England referred to in the last Annual Report as having been commenced with the aid of a special grant from the Ministry of Agriculture and Fisheries has proceeded actively during the year. A corresponding grant for this work for the coming year has been made by the Ministry.

Educational exhibits illustrating the research work of the Station have been sent during the year to the Imperial Fruit Show and the Bath and West Show.

Two field days have been held at Long Ashton during 1923. The first, on May 10th, was the Annual Tasting Day, when, as usual, a demonstration of the results of the current season's experiments on cider making was the chief feature. The second, on September 26th, was designed primarily to give fruit growers an opportunity of inspecting the experimental work on fruit culture in progress at the Station. Demonstrations of some of the most recent types of spraying machines and cultivators, the grading of apples by the Cutler grader, apple packing and tree stump blasting were included in the programme. On both occasions very large attendances were recorded, that on the latter day being the largest in the history of the Station.

Apart from these functions there were, as usual, several occasions during the year when the Station was visited by parties organised by various horticultural bodies. Included among the latter was

the Horticultural Trades Association, the annual meetings of which were held in 1923 at Bristol.

The continued increase in the number of individual visitors throughout the year is intensifying the difficulty of providing facilities for inspection of the work of the Station and consultations with the Staff without undue disturbance of the course of rescearh. The past year has furnished many occasions upon which attention to visitors has meant loss of valuable time and opportunity for investigations in progress.

An important change in the constitution of the Agricultural Research Committee of the University of Bristol, which is the body responsible for the administration of the Station, has to be recorded. Hitherto it has been composed of seventeen members, five of whom are nominated by the Council of the University, four by the Senate of the University, seven by the National Fruit and Cider Institute, and one by the Ministry of Agriculture and Fisheries. The number has now been increased to 20 to permit of the direct appointment of one member by each of the County Councils of Gloucestershire, Somerset and Wiltshire. It is regarded as important that these counties, which contribute grants from the rates to the University, should be closely associated with the latter in its activities in agricultural research and education as well as in general education. The change in constitution inevitably involves an extension of policy with regard to agricultural matters and for that reason it has been decided to change the name to that of the Agricultural Committee of the University. One of the first results of the change has been the decision to appoint an Agricultural Information Officer, whose duties will in many respects supplement those of the Advisory Officers for the Bristol Province now attached to the Long Ashton staff. The appointment of Dr. J. A. Hanley, A.R.C.S., Ph.D., of the Agricultural Department of the University of Leeds, to this post has recently been made.

A Fruit Experimental Station, designed to serve more particularly the strawberry growing industry in Hampshire, has recently been established at Botley, Hampshire, by the Hampshire County Council and the fruit growers of that county with the aid of the Ministry of Agriculture and Fisheries. The Ministry desiring to ensure co-ordination between the work of the new Station and Long Ashton, the latter is being represented on the Governing Body and members of its Staff are collaborating with the Botley Staff in drafting the schemes of experiments to be undertaken and arranging joint trials at the two Stations.

The important part taken by the administrative and assistant Staffs in securing the efficiency of the work of the Station deserves special reference and acknowledegment.

According to the arrangement as to the character of these Annual Reports indicated a year ago, many of the following articles have appeared during the year, mostly in a more detailed form, in various technical journals. In each case the name of the journal is stated in a footnote, but a general acknowledgment of the sources may be appropriately made here.

REPORT ON ADVISORY WORK, 1922-23.

The progressive increase in the advisory work of the Station, which had been conspicuous each year since the termination of the War, showed no sign of slackening during the year ended September 30th, 1923. In fact not only was the total number of enquiries received through the post (658), the highest yet reached, but the advance on the previous year's figures (180) was also greater than on any former occasion. The statistics for the past five years are given in the following table, which shows also the numbers received from each of the counties included in the Bristol Province :—

	Year ending Sept. 30th,				
	1919	1920	1921	1922	1923
Gloucester (including Bristol)	29	53	73	78	136
Hereford	6	10	22	21	62
Somerset	75	79	96	114	141
Wiltshire	6	3	10	18	66
Worcester	11	29	45	46	48
Other Areas	75	117	125	201	205
	202	291	371	478	658

Included in the figures under " other areas " are the enquiries received from Devon and Monmouth, both of which counties contribute annual grants to the Institute although not forming a part of the Bristol Province.

The figures given have reference only to enquiries by correspondence and do not include those for the willow work, the latter being separately stated in the section dealing with that work. This being the first year of that work, the inclusion of the figures in the above Table would be misleading for comparative purposes. A large proportion of advisory work is unrecorded by them, since no details are kept of the numbers dealt with verbally. Matters raised by visitors to the Station or by farmers and growers visited by members of the Staff during the course of tours in the Province come under this head. In this direction also the extension of the work is very marked. In particular, the number of visitors to the Station has increased so much as to hamper seriously the progress of the Research work, every member of the Research Staff being more or less affected.

As regards the subjects of enquiry, under all heads there is an increase, this being most striking in Agricultural Chemistry, in which the cases dealt with have nearly doubled in number as compared with the previous year. The mycological enquiries also increased by more than 50 per cent.; since these had to be dealt with by the Research Mycologist of the Station, relatively little attention could be given by him to research proper. This difficulty should be obviated in future by the appointment of an Adviser in in Mycology, which will shortly be made. The advisory work on cider and related subjects has continued to increase steadily and both in amount and character reflects the marked development of interest in cider as a beverage which has been observed outside as well as in the West of England during recent years. Economic Entomology and Pomology are subjects which, so far as figures show, have not advanced much, but such a conclusion would be erroneous, particularly in the latter case, since much has been done other than by correspondence. On the other hand the comments made by the Adviser in Economic Entomology in his report appended as to the relatively small extent to which farmers and growers avail themselves of the facilities for help which the Advisory Scheme gives them are fully justified. There is evidence indicating that this is largely due to ignorance of the scheme and that as it is becoming more widely known the enquiries are correspondingly increasing.

The enquiries relating to willows and to fruit and vegetable preservation are not included in the above statistics. A separate report on the former work is appended, while the latter are dealt with in the report of the Campden Station.

Nature of Enquiries.

Fruit Products.—The total number of enquiries answered were 212, of which many involved a complete analysis of samples and considerable experimental work. The sources of the enquiries were as follows :—

Gloucester	52
Hereford	7
Somerset	34
Wiltshire	0
Worcester	12
Other Areas	107

The work entailed visits to several cider orchards and factories. It was mainly concerned with questions arising in connection with cider and perry manufacture and the use of various kinds of apples and pears for the purpose. Considerable attention is obviously being given now by growers of table apples to the possibility of utilising lower grade fruit for cider-making.

As last year, several enquiries were received from abroad, the countries concerned being Antigua, Canada, New Zealand, South Africa, Belgium, France and Roumania.

Mycological.—The number of enquiries which have been received from the different counties during the last year are as follows :—

Gloucester	16
Hereford	22
Somerset	24
Wiltshire	7
Worcester	12
Other areas	30
Total	111

Under this heading come fungous, bacterial, and physiological diseases. The range of host plants is wide and includes fruit trees of many kinds, vegetables, and ornamental plants as well as agricultural crops.

In the spring of this year *Botrytis cinerea* was found doing very severe damage to wallflowers in the western counties. The two-year-old plants were more badly affected than the one-year-old. The reason for this is probably due to the greater density of growth in the older plants, which would retain moisture for a longer period and reduce the free passage of air within the flower beds. The fungus generally attacked the tips of the younger and inner shoots first and killed them back to the base. The fungus then spread through the crown and worked upwards inside the tissues of the outer and older shoots. In this way the whole plant was killed. Observations of the disease in different localities led to the conclusion that excessive nitrogenous manuring, bad drainage, and moist sheltered positions favoured the disease.

Several enquiries have been received concerning the diseases of plum trees. These include Silver Leaf (*Stereum purpureum*) Brown Rot and Wither Tip (*Monilia cinerea*), and the dying-off of plum trees which are five to eight years old. The latter disease has caused considerable loss in the Evesham district. So far the cause of this disease, to which the name of " Die-back " has been given, is obscure. Both *Diaporthe perniciosa* and *Cytospora sp.* have been described as causing this disease of young plum trees. Furthermore, it has been suggested that it is due to bacteria. So far infection experiments in this country with the fungi mentioned have failed to reproduce the symptoms of the disease in plum as it occurs in the field. Examination of plants from different localities show beyond doubt that the casual factor or factors, which bring about the death of the trees, are to a large extent in influenced by weather conditions, particularly in late summer and autumn.

This being so, it is evident that the factor of stock influence must be taken into serious consideration. Accordingly in the investigation into the cause of this serious disease of young plum trees which is now in hand an extensive trial of different scions on different root stocks is being made with a view of ascertaining the degrees of susceptibility.

The following table indicates the nature of the majority of the enquiries and associated fungi which have been received during the year :—

Host Plant.	Nature of Trouble.
Apple	Water Core (physiological).
	Leaf Scorch (physiological).
	Myxosporium Canker (*Myxosporium corticolum*).
	Scab (*Venturia inaequalis*).
	Canker (*Nectria galligena*).
	Crown Gall (*Bacillus tumefaciens*).
Asters	Wilt (*Cephalosporium sp.*).
	Mildew (*Oidiopsis sp.*).
Barley	Late Blight (*Helminthosporium teres*).
Celery	Hollow Stick (physiological).
	Leaf Spot.
Beans	Chocolate Spot (*Bacillus lathyri*).
Black Currant ..	Rust (*Cronartium ribicola*).
	American Mildew (*Sphaerotheca mors-uvae*)
	Corticium solani.
Cherry	Blossom Wilt (*Monilia cinerea*).
Gooseberry	American Gooseberry Mildew (*Sphaerotheca mors-uvae*).
Grape	Mildew (*Uncinula necator*).
Oats	Mildew (*Erysiphe graminia*).
	Leaf Spot (*Helminthosporium avenae*).
Plum	Die-back (cause unknown).
	Silver Leaf (*Stereum purpureum*).
	Witches Broom (*Exoascus instititiae*).
	Brown Rot (*Monilia cinerea*).
	Fomes igniarius.
Potato..	The Common or Brown Scab (*Actinomyces scabies*).
Peach	Silver Leaf (*Stereum purpureum*).
	Mildew (*Sphaerotheca pannosa var. persicae*).
	Leaf Curl (*Exoascus deformans*).
	Brown Rot (*Monilia cinerea*).
Pear	Leaf Blister (*Taphrina bullata*).
	Scab (*Venturia pirina*).
	Eye Rot.
Tomato	Stripe Disease (*Bacillus Lathyri*).
	Botrytis Rot (*Botrytis cinerea*).
	Sleepy Disease (*Verticillium albo-atrum*).
Turnip..	White Rust (*Cystopus candidus*).
Wallflower	Botrytis Rot (*Botrytis cinerea*).
Wheat..	Bunt (*Tilletia tritici*).
	Whiteheads (*Ophiobolus graminis*).

Pomological.—The sources of the written enquiries under this head were as follows :—

Gloucester (including Bristol)	14
Hereford	2
Somerset	17
Wiltshire	1
Worcester	7
Other areas	39
	80

The figures give an inadequate idea of the large volume of advisory work which the Station is now doing under this head in the Bristol Province, most of which is dealt with by personal interviews with growers who visit the Station or are seen on their own farms. The subjects arising are much the same from year to year. During that under review no point of outstanding interest has arisen. Strawberry growing enquiries have once more been proportionately numerous, especially those in which the " red plant " problem has been concerned, to which further reference is made in the entomological section of the Report.

Shows.—Exhibits illustrative of the research work in progress at the Station have been sent during the year to the Imperial Fruit Show at the Crystal Palace and the Bath and West Show at Swansea. These were attended by members of the Staff of the Station.

In addition, assistance was given to the exhibits of the respective County Agricultural Education Departments at the various County Shows in the Bristol Province by the loan of material.

The following three sections, dealing with Agricultural Chemistry, Economic Entomology, and Willow Culture, have been respectively contributed by Mr. T. Wallace, Mr. E. Ballard and Mr. H. P. Hutchinson, the Advisors in those subjects.

Agricultural Chemistry.

The number of requests for advice received during the year was 148. The sources and nature of these enquiries, together with their special points of interest, are given below.

SOURCES OF ENQUIRIES.

Gloucester (including Bristol)	32
Hereford	17
Somerset	37
Wiltshire	53
Worcester	6
Other Areas	3
Total	148

NATURE OF ENQUIRIES.

(1) *Soil Problems.*

(*a*) *Soil Manurial Problems.*

Pastures and Meadows	26
Arable Soils	104
Fruit Soils	9
Garden Soils	2
Hopyard Soils	1
Market Garden Soils	3
Total	145

(*b*) *Miscellaneous Soil Problems.*

Soil conditions causing chlorosis of fruit trees ..	4
Soil conditions in cases of leaf scorch	7
Soil conditions in cases of crop failures	8
Suitability of soils for fruit growing	5
Total	24

(2) *Miscellaneous Enquiries.*

Agricultural value of samples of lime, limestone and chalk	18
Potash content of samples of wood ashes	2
Purchase of manures	3
Manurial value of samples of sewage sludge	2
Manurial value of samples of shoddy	2
Manurial value of samples of paper mill waste ..	1
Comparative manurial value of samples of low and high grade basic slags	1
Manurial value of residue from spent mushroom beds	1
Fineness of grinding of sample of mineral phosphates	1
Cause of "cheese tainting" from pastures	1
Treatment of stock on "teart" land	1
Eradication of saffron from meadows..	2
Cause of failure to germinate of a sample of wheat ..	1
Treatment of "green patch" of tomatoes	1
Composition of sample of sulphate of copper	1
Analyses of feeding stuffs in cases of poisoning of stock	2
Value of cocoa factory refuse as pig feed	1
Feeding values of samples of mangels	1
Total	42

Number of Samples examined in dealing with Enquiries.

Soils	217
Samples of lime, limestone and chalk	18
Miscellaneous samples	10
Total	245

Number of farms visited in carrying out advisory work— 28

OBSERVATIONS ON ENQUIRIES.

The number of enquiries submitted during the year shows a large increase over those of previous years.

A large proportion of the samples submitted from Wiltshire consisted of samples of soils suspected of being deficient in lime and of samples of lime materials. These samples were collected by the County Organiser from students attending his lectures in certain districts of the county where soil acidity is prevalent—generally on soils derived from the Lower Greensand formation. In the course of these lectures the Organiser emphasised the great need for lime in the local soils and arranged for the collection of any samples of soils and "lime" on which information was desired.

(1) *Soil Enquiries.*

On the whole the enquiries have been of a similar nature to those received in previous years. Thus in the majority of problems

submitted relating to arable soils it was found that poor cropping was associated with soil acidity.

Some interesting cases of poor cropping on Lias and Oolite soils in Gloucestershire and on Chalk soils in Wiltshire have been investigated. One very interesting case of a crop failure in Somerset was reported. This was a case of a total failure of the swede crop in spite of liberal manurial treatment to the crop on a soil derived from the Upper Sandstone formation at Fitzhead, Somerset. It was found that the ground had been ploughed a little deeper than usual for the swede crop with the result that the newly turned up material proved toxic to the crop.

Enquiries on the subjects of the improvement of pastures and meadows have generally related to the desirability of applying phosphates and lime for this purpose.

Of the four cases of chlorosis of fruit trees submitted, two cases related to trees growing on soils derived from the Dolomitic Conglomerate, one case to trees on a Mountain Limestone soil, and one case to trees on an Oolite soil.

Experiments to discover a remedy for this condition have been arranged.

(2) *Miscellaneous Enquiries.*

It will be seen from the list of these enquiries that although they are very varied the great majority fall into the following categories :

(1) Enquiries relating to the manurial value and condition of fertilising materials.

(2) Enquiries relating to pastures.

(3) Enquiries relating to feeding stuffs.

Special Investigations in Progress.

(1) Field Experiments on "The Eradication of Bracken from Poor Moorland Pastures."

This investigation has been continued in conjunction with the Experiments Committee of the Bath and West and Southern Counties Agricultural Society.

(2) Field Experiments on "The Improvement of Poor Pastures where the Soils are Acid in Reaction,"—in conjunction with County Organisers and various farmers.

(3) Field Experiments as under on "The Manuring of Fruit Trees in Plantations and Grass Orchards."

(*a*) Effect of dung and potash manures on leaf scorch—in conjunction with the County Organiser for Worcester, the Horticultural Instructor for Hereford, and various fruit growers.

(*b*) Effect of phosphatic manures in a case where deficiency in phosphoric acid is indicated—in conjunction with the County Organiser for Worcester.

(*c*) Effect of autumn and spring dressings of nitrogen on apple trees—in conjunction with the County Organiser for Worcester.

(*d*) Effect of dressings of phosphates and potash on apple trees in grass orchards—in conjunction with the Agricultural Organiser for Gloucester.

(4) Field Experiments on " The Effect of Spraying with Sulphate of Iron on Chlorosis of Apple Trees and Black Currant Bushes "—in conjunction with the Horticultural Superintendent for Somerset.

(5) Experiments on " Liming of Arable Soils " under the scheme of the Ministry of Agriculture and Fisheries. Centres have been arranged as under :—

Hereford	3 centres
Gloucester	2 ,,
Worcester	1 centre

(6) Survey of Fruit Soils on the Old Red Sandstone formation in the West Midlands (under the scheme of the Ministry of Agriculture and Fisheries).

During the season of 1923 a preliminary survey was made of the soils of the area over which the investigation is being carried out. 267 soil samples were collected and the various points of these bearing on the particular problem are being examined in the laboratory.

Economic Entomology.

With the appointment of an Entomologist whose whole time can be given to Advisory Work it has been possible to get into closer touch with farmers and fruit growers and to obtain a clearer idea of the distribution of various insect pests in the different centres. It is hoped that as a result of coming into personal contact with growers on their own plantations an increasing use will be made of information which is available at the Institute.

The number of letters dealt with during the year was 80, the majority being from fruit growers. Somerset, as might be expected from its proximity to the Station, sent most, while Wiltshire sent one letter and one verbal message. The distribution of the enquiries which were dealt with is as follows :—

Gloucester	12
Hereford	13
Somerset	21
Wiltshire	2
Worcester	9
Other areas	23
Total	80

The very small amount of correspondence shows that not nearly as much use is made of the Station as there might be.

Naturally these figures give only a small indication of the actual amount of advisory work accomplished, a great many questions being dealt with in person, as a visit to a plantation to tackle one problem invariably leads on to the discussion or discovery of others, showing once more, if evidence were needed, the value of personal contact.

One of the chief difficulties of science applied to agriculture is to get the work of the laboratory into the field so that it may be used by the growers. It is in a general way very difficult to get people to write for advice or to state their troubles. As a rule it is only when making personal visits that one hears what these various troubles are. Conversely, a member of the Staff constantly in the field is able to keep the research workers in touch with the situation as it appears to the grower. During the nine months since the appointment of an advisory entomologist over sixty visits have been made either in reply to requests for advice or for the purpose of getting acquainted with farmers, fruit growers, and market gardeners.

One field experiment was organised and carried out, through the courtesy of a grower in Hereford, on spraying for Logan Beetle, *Byturus tomentosus*. This experiment was an extension of work already carried out at Long Ashton, where a very successful control of the beetle had been obtained. It was realised that before pushing the matter further it should be tried on a scale greater than was possible at Long Ashton.

Unfortunately, there was an unexpected scarcity of beetles in the plot selected for the experiment, but a very marked difference in the amount of infection between sprayed and unsprayed areas was shown. In the light of experience gained this year it is hoped that it will be possible to continue the experiment. The results are as follows :—

	Sprayed.	*Unsprayed.*
Percentage damaged ..	7%	21·4%
	14%	32·5%

The clay-coloured weevil, *Otiorhynchus picipes*, which had annually caused much damage to recently grafted stocks at Cheltenham, was completely controlled by spraying with lead arsenate. Preparations to meet it had been made in advance, and spraying was undertaken almost as soon as the beetle made its appearance.

The pests which created the most havoc this season were various species of Aphids, which were exceptionally destructive to plums, apples, currants and gooseberries. There was a very marked

absence of Coccinellid and Syrphid larvæ until late in the seasons when all the damage had been done. This was presumably due to the cold early summer.

The abundance of apple sucker eggs, seen early in the year, gave promise of a heavy attack, which was amply fulfilled. Those trees which had been sprayed with a certain proprietary egg-killing wash were absolutely free, thus confirming the results obtained at Long Ashton.

The majority of grass orchards seen had suffered far less from aphids than those which were cultivated. This applied also to part of a plum orchard which had been under lucerne for three years.

In many parts of Hereford and Gloucester Winter Moth did a great deal of damage in spite of grease banding; spraying had to be resorted to. A certain number of growers are of the opinion that banding is not profitable as spraying has to be done in any case, but it would appear that spraying should not be necessary if banding is done in time. It is possible that Winter Moth came up earlier last year (1922) than usual, but on this point information is lacking.

Another line of investigation which was taken up late in the season in response to an appeal for help, was that of the pests of willows in South Somerset, where some 3,500 acres are devoted to willow growing.

Two species of the genera *Phytophaga*, *Phyllodecta* and *Calerucella* had done great damage to withy beds near Langport, reducing the value of the crop by about 50 per cent. As so often happens, the request for help came too late for anything to be done, but it is proposed to take the matter in hand next year.

The problem of "red plant" in strawberries, of which complaints were received from Cheddar, Tamar Valley, Hants, and other places, and which has been under observation for some time, was finally solved so far as identification of the casual organism is concerned. The more difficult problem of control is now being worked at, as is also the life history of the nematode which is the cause of the disease.

It has been finally proved that "red plant" and the already well-known "cauliflower" disease of strawberries are only part of the same disease, though different symptoms of it. Plants which have been marked down as "red" early in the season have later developed "cauliflower" symptoms and all intermediate stages have been identified. The results of this work have been published in the "Journal of Pomology" for July, 1923, and are also included in the present Report.

It will be observed that nearly all pests dealt with are those affecting fruit growers. This is due to two factors, firstly, that nearly the whole of the Bristol Province is devoted to some form of dairy farming or fruit farming, the latter often combined with market gardening, and, secondly, to the fact that farmers do not realise

yet that Long Ashton is able to cater for their needs agriculturally as well as horticulturally for those of the fruit farmer. There remains the larger number of others who do not realise that it is possible to get advice from anywhere.

Willow Culture and the Utilisation of Willows.

The total number of enquiries received during the year was 78, distributed as follows :—

Gloucester (including Bristol)	7
Hereford	0
Somerset	24
Wiltshire	2
Worcester	1
Other areas	44
	78

(*a*) *For the period* 1*st October*, 1922, *to* 12*th March*, 1923.

Enquiries.

Thirty-one enquiries on willow cultivation and crop management were answered. The advice sought was chiefly concerned with :—

(1) Suitable varieties of willows to plant, method of planting and general crop management under sewage conditions.

(2) The management of Cricket Bat willow plantations and methods of propagation of young trees.

(3) The marketing of willow rods.

(4) Suitable varieties for planting.

(5) Remedial measures for resisting Canker.

At the request of willow growers, visits were made in company with Mr. A. D. Cotton, the Ministry's Mycologist, to the Somerset willow-growing centre, with the object of ascertaining the cause of a serious spread of canker and of suggesting remedial measures. A circular advocating methods of treatment was prepared and forwarded to willow growers in the affected districts.

Ten enquiries were made by the Rural Industries Intelligence Bureau and one visit was paid on behalf of the Bureau to Paverham in order to ascertain the conditions of the willow-growing and basket-making industries in the district.

One public lecture on willow cultivation was given in Gloucestershire.

(*b*) *For the period* 12*th March*, 1923, *to September* 30*th*, 1923.

Enquiries.

Forty-seven enquiries were answered, and twenty-three visits made in connection with crop difficulties.

The enquiries were concerned with :—

(1) Crop management.

(2) Fungus and Insect attacks.

(3) Suitability of varieties for different soil conditions.

(4) Cricket Bat willow cultivation.

(5) Classification of varieties.

Fungus and Insect Attacks.

The serious canker outbreak in Somerset in the autumn of 1922, which was reported to the Ministry, did not recur in the autumn of 1923, but the spring attack occurred as in previous years.

A serious attack of canker due to *Physalospora*, was reported from Lancashire, where considerable damage had been caused on a hybrid variety locally grown and known as " Mawdsleys." Growers are being advised, as a result of observations made on the behaviour of the fungus,

(1) to cut closely,

(2) to avoid leaving diseased twigs on the ground after cutting,

(3) to spray the young crop in the spring with a fungicide.

Beetle attacks occurred on an extensive scale in the Somerset area. Visits were made to the affected crops in company with the Station's Advisory Entomologist and the beetles were identified as :—

(1) *Phyllodecta vitellina* on *Salix viminalis.*

(2) *Galerucella lineola* on *Salix triandra.*

Arrangements were made with the growers for the carrying out of remedial trials on the first appearance of the insects in 1924.

" Button Top " disease due to attacks by *Cecidomia sp.* occurred in Somerset, but less damage was done by the insect than in previous years.

Twenty-three enquiries were made in regard to the cultivation of the Cricket Bat willow—*Salix alba* var. *caerulea.* Suitable sets of this willow are now difficult to obtain and prices are high—£5 per 100 long sets being asked at the present time.

The basket-making industry of the country is depressed largely owing to the general depression in other industries, with the result that willow growers are experiencing difficulty in disposing of their willows at prices commensurate with the costs of production. Complaint has been made by Somerset growers that the prices

they realise are too low in comparison with the prices paid by basket-makers because of the interposition of willow merchants to whom they have been accustomed in the past to sell their crops.

A marketing scheme, whereby the growers will supply the basket-makers of the country direct, *i.e.*, without the agency of the intermediate merchant, is contemplated.

Willows and willow products were exhibited at the Bath and West Agricultural Show and on two public inspection days at the Research Station.

A visit by the members of the National Cane and Willow Workers' Association was made to the Station when the willow plantation was inspected and the various aspects of willow cultivation discussed.

THE MANURING OF POOR PASTURES IN THE BRISTOL PROVINCE.

By T. Wallace.

The various problems relating to the management of grassland assume great importance in the five counties constituting the Bristol Province—Gloucestershire, Herefordshire, Somerset, Wiltshire and Worcestershire—where such a large acreage of land is utilised for permanent pasture and meadows in the production of milk and the breeding and rearing of cattle and sheep. In view of the great importance of these matters to the farmer, the various problems relating to the manuring of pastures in this area are being studied in connection with the Advisory Service of this Station.

This work has been in progress over four seasons and it is thought that the data obtained to date, though very incomplete, will be helpful to farmers and others who are endeavouring to improve their pastures.

Before presenting these data it will not be out of place to review very briefly some of the main results of experiments obtained on the manuring of pastures in the United Kingdom and to give some broad idea of the various aspects of this problem in the area under consideration. A list of references is appended for readers requiring more detailed information on the above experiments.

Results of Experiments in the United Kingdom.

The main fact which has been brought out in practically every series of experiments has been the paramount importance of phosphatic fertilisers in effecting improvement of the herbage of pastures.

Phosphates appear to effect this improvement chiefly by stimulating the growth of leguminous plants, especially wild white clover, though it also appears that they may considerably increase the feeding quality of the grasses by direct stimulation of their growth and by indirect stimulation through their action on the leguminous plants of the pasture.

Basic slag and certain of the rock phosphates from North Africa have been shown to be, as a general rule, the most efficient of the phosphatic fertilisers for the purpose. Superphosphate alone has produced results equal to those produced by basic slag on some

soils containing large supplies of carbonate of lime, but generally it has not be as efficient on limeless soils unless used in conjunction with lime.

The results with bone manures have been rather inconsistent.

Potash manures have often produced no results whatever on pastures where normally they would be expected to effect improvement, but in many cases they have proved valuable, especially on light soils and peaty soils.

Lime, when used alone, has generally produced no results, but when used in conjunction with phosphatic manures has often proved of great value.

Where no improvement has been effected from the addition of phosphates, the failure has generally been associated with the total absence of leguminous plants from the area or with the presence of a thick mat of coarse grass and partly decayed organic matter on the surface of the pasture which prevented the development of the useful leguminosæ.

The Problem in the Bristol Province.

The problem in this province is to ascertain how far the results obtained in previous experiments in other parts of the country are applicable to the various soil and climatic conditions which are met with in this area.

The soils of the area are very varied and of very diverse origin. There are soils derived from every geological series between the Upper Cretaceous series and the Wenlock series, whilst there are numerous drift and alluvial soils. From the point of view of texture, every type of soil is represented from the light chalk, sandy and gravelly soils to very heavy tenaceous clays. As examples of light soils the Chalk soils of the Wiltshire Downs, the Oolite soils of the Cotswolds, the light sandy soils of the Greensand and New Red Sandstone series, and the numerous river deposits which are present over the area, will serve ; the loams are widely represented by the soils of the Keuper Marl series, and by the heavier soils of the Old Red Sandstone formation ; lastly the heavy clays derived from the Lower Lias series, which are widely distributed over the area and certain heavy alluvial soils will serve as examples of the heaviest types of soils.

As regards the lime contents of the soils, these cover a very wide range, the soils derived from the Chalk and Oolite formations often containing very high percentages of carbonate of lime—up to 60% or 70%—whilst many of the soils derived from the sandstone formations, contain no carbonate of lime and are strongly acid to litmus.

As regards the climate of the area, the most notable fact in connection with the problem under consideration is the large difference

between the annual rainfall in the south-west and north-east portions of it—reaching about 40 inches in the south-west, whilst averaging less than 30 inches in the north-east.

It would be expected under such varying conditions of soils and rainfall that pastures throughout the area would respond in different ways to any one treatment and hence it appeared desirable in studying the problem of the manuring of pastures in the province to collect soil data and to make observations on the effects produced on the pastures on these soils by different manures on as many soil types as possible in the various districts.

Methods Adopted in Collecting Data.

The soil data which are presented in this paper have been obtained either from plots where experiments have been carried out by various Authorities or from cases which have come under the writer's notice while carrying out advisory duties. Very often in the latter cases the farmer has carried out the treatment as the result of a request for advice and sometimes the manuring has been carried out prior to the visit to the farm.

No data have been collected as to the actual financial gains or losses resulting from the treatments, but it has merely been noted whether substantial improvement to the herbage has resulted from the treatment as judged from the development of leguminous plants and the manner in which stock show increased liking for the herbage.

An attempt has been made in every case to obtain the following soil data : Moisture on air-dried sample, loss on ignition, mechanical composition, available potash*, available phosphoric acid,* carbonate of lime content or acidity (lime requirement). On many of these samples it has not been possible to carry out the whole of these determinations and where the samples have been taken after the manures have been applied—generally phosphates—the figures obtained for available phosphoric acid have, of course, no significance from the point of view of indicating probable deficiencies or otherwise of this material in the soils, but have been obtained only as a matter of interest.

Following these lines, the data already obtained are presented in Tables I. and II., and the various cases are discussed in detail below.

It should be said at this point that no cases have yet been studied to determine the responses obtained to the application of potash manures, the whole of the cases referring to centres where phosphates or lime have been applied.

Further, at some centres for which soil data are presented, no manurial treatments have been given. In such cases the data are

* Soluble in 1% Citric Acid Solution.

Table I.

No. of Sample.	Locality.	Geological Formation.	Description of Soil.	Moisture %	Loss on Ignition %	Available Potash (K_2O) %	Available Phosphoric Acid (P_2O_5) %	Carbonate of Lime ($CaCO_3$) %	Lime Requirement %
1	Almondsbury, Gloucestershire	Lower Lias	Heavy Clay			0.015	0.0054	2.0	Nil
2a	Maisemore Gloucestershire ..	Ditto	Ditto	4.33	9.00	0.025	0.0012	14.65	Nil
2b	" "	Ditto	Ditto	3.35	7.26	0.012	0.0219	7.70	Nil
3	Coaley, Gloucestershire ..	Ditto	Ditto	9.14	15.60	0.012	0.0097	Nil	0.439
4	Nempnett, Somerset	Ditto	Ditto			0.0152	0.0088	Nil	0.338
5	Yeovil, Somerset	Ditto	Ditto	5.79	12.08	0.0139	0.0093	1.18	Nil
6	Wootton Fitzpaine, Dorset ..	Ditto	Ditto	3.46	10.18	0.0279	0.0091	Nil	0.640
7	Tenbury, Worcestershire ..	Old Red Sandstone ..	Heavy Loam	2.12	5.08	0.0050	0.031*	Nil	Nil
8	Tyllwydd, Monmouth	Ditto	Ditto	1.64	4.35	0.0095	0.0078	Nil	0.146
9	Suckley, Worcestershire ..	Ditto	Fine Sandy Loam ..	1.97	4.96	0.0046	0.0121	Nil	0.185
10	Bromyard, Herefordshire ..	Ditto	Heavy Loam	2.59	5.86	0.0106	0.0051	0.5	Nil
11	Lydney, Gloucestershire ..	Ditto	Fine Sandy Loam ..	1.96	7.70	0.0174	0.0133	Nil	0.96
12	Bridge Sollars, Hereford ..	Ditto	Sandy Loam	1.77	5.34	0.0055	0.0127	Nil	Slightly acid
13	Winscombe, Somerset	Ditto	Sandy Loam, with Sand stones	2.64	7.74			Nil	0.376
14	Shepton Mallet, Somerset ..	Ditto	Ditto	3.15	10.16	0.0134	0.0106	Nil	0.584
15	Chipstable, Somerset	Devonian	Ditto	2.57	8.72	0.0330	0.0301*	Nil	0.451
16	Ditto, ditto	Ditto	Sandy Loam	3.10	10.44	0.0090	0.0055	Nil	0.314
17	Wrington, Somerset	Keuper Marl	Fine Sandy Loam			0.0084	0.0150	Trace	Nil
18	Newent, Gloucestershire ..	Ditto	Ditto	1.56	5.91	0.0095	0.0088	Nil	0.22
19	Red Marley, Gloucestershire ..	New Red Sandstone ..	Light Sandy Soil	0.76	2.26	0.0058	0.0170	Nil	0.030
20	Nailsea, Somerset	Peat over Coal Measures	Coarse Sand with Peat ..	11.40	21.32	0.0071	0.0123	Nil	0.557
21	Abberley, Worcestershire ..	Coal Measures ..	Clay	4.04	11.94	0.0136	0.0044	Nil	0.360
22	Nailsea, Somerset	Ditto	Ditto	2.60	9.06	0.0171	0.0052	Nil	0.639
23	Frampton Cotterell, Glos. ..	Ditto	Fine Sandy Loam	1.84	7.61	0.0094	0.016*	0.44	Nil
24	Paulton, Somerset	Rhaetic Beds ..	Sandy Loam	2.44	8.59	0.0216	0.0149	Nil	0.577
25	Winsford, Somerset	Devonian	Clay Loam with Shales ..	2.50	8.47	0.0105	0.0097	Nil	0.770
26	Long Ashton, Somerset ..	Carboniferous Lime-stone	Clay Loam	3.68	8.78	0.0076	0.0050	Nil	0.562
27	Ditto, ditto	Millstone Grit ..	Medium Loam with Grits..	2.57	7.04	0.0057	0.0108	Nil	0.400
28	Turlake, Devon	Carboniferous Shale ..	Clay Loam..	2.92	8.10	0.0102	0.0054	Nil	0.324
29	Bowerchalke, Wiltshire ..	Clay with Flints ..	Clay containing Flints ..	3.03	5.64	0.0075	0.0050	4.76	Nil
30	Malmesbury, Wiltshire ..	Oxford Clay	Heavy Clay	4.56	9.50	0.0092	0.0218	Nil	1.41
31	Ditto, ditto	Ditto	Ditto	4.76	11.48	0.0162	0.0088	Nil	1.37
32	Frome, Somerset	Greensand	Coarse Sand	3.10	9.06	0.0103	0.0115	Nil	0.658
33	Shrawley, Worcestershire ..	Alluvium	Fine Sandy Loam ..	2.26	5.82	0.0139	0.0057	Nil	0.257
34	Little Hereford, Herefordshire	Teme Alluvium ..	Ditto	2.11	5.38	0.0110	0.0073	Nil	0.297
35	Tenbury, Worcestershire ..	Ditto	Sandy Loam	3.08	7.36	0.0091	0.012	Nil	0.386
36	Orchard Portman, Somerset ..	Alluvium	Gravelly Loam	4.40	7.22	0.0193	0.0021	10.40	Nil
37	Madley, Herefordshire	Glacial Drift over Old Red Sandstone ..	Fine Sandy Loam	2.92	4.24	0.0050	0.0184	Nil	Nil
38	Oldcastle, Herefordshire ..	Ditto	Ditto	2.43	7.77	0.0085	0.0108	Nil	0.417

* Slagged previous to sampling.

Table II.

	No. of Sample.							
	No. 1	No. 5	No. 6	No. 8	No. 9	No. 11	No. 15	No. 19
	%	%	%	%	%	%	%	%
Surface Soil—								
Stones in Sample..	Nil	Nil	Nil	Nil	0·50	2·00	20·00	3·50
Fine Gravel ..	0·65	0·28	0·31	1·08	0.40	0·74	9·17	1·66
Coarse Sand ..	12·29	1·60	0·71	2·15	3·35	24·06	9·66	30.62
Fine Sand ..	19·51	6·69	21·02	29·34	32·16	30·57	21·17	49·74
Silt..	13·24	9·79	23·85	23·68	23·60	11·27	24·27	4·57
Fine Silt	16·42	26·98	24·65	22·40	22·98	16·12	18·20	5·08
Clay	24·33	34·22	13·86	14·31	9·36	6·82	4·17	4·55
Subsoil—								
Stones in Sample	—	Nil	Nil	Nil	Nil	—	60·00	1·30
Fine Gravel ..	—	Nil	0.32	0.41	0.23	—	14·53	1·74
Coarse Sand ..	—	0·89	0·80	2·09	3·77	—	9·65	32·79
Fine Sand ..	—	4·49	24·88	25·06	38·91	—	20·65	48·89
Silt..	—	7·79	21·68	23·90	21·42	—	19·58	4·40
Fine Silt	—	25·00	22·74	25·94	19·80	—	22·04	6·00
Clay	—	43·26	20·41	16·29	10·83	—	7·82	4·20

	No. of Sample.					
	No. 23	No. 26	No. 27	No. 28	No. 37	No. 38
	%	%	%	%	%	%
Surface Soil—						
Stones in Sample	Nil	Nil	13·80	7·80	7·50	1·70
Fine Gravel	1·07	1·60	4·09	3·50	1·72	1·25
Coarse Sand	11·35	4·45	8·97	10·97	6·09	2·65
Fine Sand	34·93	27·61	30·92	21·12	22·30	21·95
Silt	17·44	14·60	15·89	16·38	31·18	32·65
Fine Silt	18·08	18·00	16·89	25·32	25·25	23·50
Clay	5·32	19·72	10·49	10·46	7·50	6·60
Subsoil—						
Stones in Sample	Nil	Nil	19·00	1·00	—	10·00
Fine Gravel	0·96	2·08	8·66	2·89	—	3·24
Coarse Sand	11·80	4·83	9·82	3·70	—	3·78
Fine Sand	34·49	25·92	26·22	7·88	—	20·66
Silt	16·89	12·78	11·41	12·95	—	34·25
Fine Silt	18·92	16·74	14·81	33·30	—	23·30
Clay	9·70	28·11	20·81	30·90	—	7·80

of soils from poor pastures typical of some particular district, and they are included as showing possible reasons for the poor quality of such pastures.

Three of the centres for which data are given are outside of the Bristol Province.

Discussion of Data.

For purposes of discussion, the various cases are grouped in the tables according to the geological origins of the soils, as under this system the soils fall into more or less well defined types which admit of comparisons.

Samples Nos. 1 to 6 are from the Lower Lias formation. These soils are typical of the Lias clays of the area, which are very widely distributed in Worcestershire, Gloucestershire and Somerset. The amount of clay in this type generally varies from 15% to 35% in the surface soil, and whilst the amount of carbonate of lime in the soil is generally high, this substance may be entirely lacking from the soil in certain areas. Pastures on this type of soil are often excellent, but in certain areas the herbage may be very thin and sparse, or, if the soil lies wet the grass may grow very rankly and be of little feeding value. The examples given are from fields where both types of herbage are found and in all cases—excluding Nos. 2a and 2b, where no treatment has been given—the application of phosphatic fertilisers—generally basic slag—has resulted in very marked improvement, those at Almondsbury and Nempnett being especially striking.

Cases Nos. 2a and 2b are of interest as showing the difference in the content of available phosphoric acid in soil samples from two parts of the same field—sample No. 2a being from the bad portion and No. 2b from the good portion.

The sample from Coaley was taken from a pasture with a very bad reputation, which responded to basic slag. This is a case where the herbage of the pasture before slagging was extremely coarse and ungrazed, and where since the application of slag the stock have eaten down the coarse grasses, and a good plant of clover has become established.

No. 6 sample was obtained from a bracken covered area, and is typical of an area which has not responded to liming, but which has been greatly improved by basic slag.

Samples Nos. 7 to 12 are typical examples of the close textured loams of the Old Red Sandstone series, which are widely distributed in Herefordshire and Worcestershire, and which occur to a less extent in Gloucestershire. These soils are generally deficient in lime excepting at points where cornstones occur. Pastures on soils of this type re-act very markedly to basic slag and cases have also been observed where mineral phosphates have given good results.

The writer had an opportunity during the season of 1923 of making observations on numerous pastures on this type of soil, and in every case where trials had been made phosphates appeared to have effected great improvement.

Of the examples given, No. 10 is of interest as being a pasture in very poor condition, and No. 11 as an example of a soil with a very high lime requirement on which basic slag has produced a luxuriant development of wild white clover.

No. 12 is a case of a field which for two seasons after seeding down produced no clovers after which two dressings of basic slag, each at the rate of 5 cwts. per acre, were given, and resulted in the whole field being covered with a carpet of clovers.

Examples of soils derived from the Old Red Sandstone in Somerset are furnished by samples Nos. 13, 14. The samples were taken from the neighbourhood of the Mendips, where small areas of Old Red Sandstone soils occur. The soils over these areas are generally light, sandy and shallow, and are, as a rule, limeless and strongly acid in reaction. Pastures and meadows on this type of soil are naturally extremely poor.

Sample No. 13 is from a field which in three years was converted from a useless bracken covered tract into an excellent pasture, over which there was a carpet of wild white clover, by means of summer cutting of the bracken, applying basic slag at the rate of 5cwts. per acre, and subsequently grazing heavily with sheep.

No. 14 is from an extensive tract of land which a farmer is desirous of taking in hand, and where the soil is very similar to that at No. 13 centre.

Devonian soils occurring in the west of Somerset are represented by samples Nos. 15, 16 and 25.

Nos. 15 and 16 are from centres where experiments are in progress under the Agricultural Education Association to test the relative efficiencies of various types of basic slags and mineral phosphates for improving grassland.

At both centres all these various phosphates have effected great improvement in the quality of the herbage. The sample from No. 15 was taken from plots to which phosphates had been applied.

Two examples from the Keuper Marl formation are given in Nos. 17 and 18. No. 17 was taken from a field which had been mown for hay for many years and in which the herbage was in very poor condition. Considerable improvement was effected by basic slag. No. 18 is from a poor pasture infested with meadow saffron. which the farmer wishes to improve.

No. 19 is a sample from a poor meadow which is representative of the poorer meadows on a type of soil derived from the New Red Sandstone series which occurs around Newent, in Gloucestershire. The soil over this area is very light and sandy and often thin and

overlying sandstone rock. Analyses of soil samples from this area show that for the greater part this type of soil has a fairly high "available phosphoric acid"—often 0.03%—contains some carbonate of lime, and is not acid. Queries have often been received regarding the reasons for the poor cropping on arable soils and the poor condition of grassland on this type of soil, and a trial to test the effects of kainit and slag on the example given has been arranged. The field is to be kept grazed during the period of the trial.

Examples from various types of soil derived from the Coal Measures, are given in samples No. 20 to No. 23. Such soils occur in relatively small patches in various districts of the province. Generally they are of a sandy or clayey nature and frequently are soils as in samples Nos. 20 to 23. No. 20 is from a very poor field which is generally cut for hay and the aftermath grazed until the field becomes too wet for stock. It was never manured of recent years until two years ago, when a dressing of bone meal was applied. The herbage appears to have been greatly improved by the dressing, clovers having appeared, whilst the colour of the grasses has been changed from a dull bluish green to a bright green. Slag was found to be very effective on a portion of the field from which sample No. 21 was taken when the field was used as a pasture. Where the pasture was untreated the herbage was very thin and of little value. The pasture was ploughed up during the war and on the area from which the sample was taken, total failures of successive oat, wheat and bean crops resulted. No. 22 sample was taken from a poor pasture, the greater part of which had been previously waterlogged, and over which area there is a thick mat of useless grasses and rushes. On a portion of this field, where the mat is not so thick, basic slag has been applied and has improved the herbage greatly. The centre is marked for further trials with lime and slag on the "mat" area.

The herbage of the pasture from which No. 23 sample was taken appeared to be of excellent quality, containing much clover, following the application of basic slag. The field was not seen previous to slagging, and the soil sample examined was taken after the slag had been applied.

Sample No. 24 is from the Rhætic Beds in Somerset. The sample is from a pasture which was in very poor condition, the grasses being very poor and clovers very sparse. Trials with slag and lime were carried out last season and the farmer reports that slag is effecting improvement.

Sample No. 25 was taken from a very poor pasture and is typical of the clay with shales soils derived from the Devonian formation which occur over the hilly area to the north of Dulverton. The grassland over this area is very hilly and much of it is very poor and covered with bracken. The writer has observed several cases

where pastures have been greatly improved by basic slag on this type of soil. A trial with phosphates and lime has been arranged for the coming season on a very sour pasture in this area.

No. 26 is representative of the soils overlying the masses of Mountain Limestone which occur in Somerset. They are generally found at high altitudes and are sour and covered with bracken. On the pasture from which this sample was taken a dressing of high grade basic slag at 7 cwts. per acre produced a luxuriant growth of wild white clover, whilst no improvement can be observed after two seasons from a dressing of ground burnt lime applied at the rate calculated to satisfy the lime requirement given in Table I.

The centre from which sample No. 27 was taken was covered with a dense growth of bracken three years ago. This has been cleared by cutting, and trials with phosphates and lime have been carried out with a view to converting the area into a useful pasture. Basic slag, supplying 150 lbs. of phosphoric acid (P_2O_5) per acre, followed by grazing with sheep, has converted a portion of the area into a useful pasture full of white clover, whilst Nauru phosphate, applied to a second portion to supply the same amount of phosphoric acid (P_2O_5) as the slag, has also encouraged the leguminous plants, but has not been so effective as slag. Another portion of the area which received a dressing of ground burnt lime, at the rate of 48 cwts. per acre, does not appear to have responded to this treatment up to the present, and the stock do not graze it any better than where no manure has been applied.

Sample No. 28 is from a very poor pasture in Devon and is included as similar poor pastures exist in the south west of Somerset on this type of soil. The figure obtained for available phosphoric acid suggests that these pastures will probably be improved by phosphatic fertilisers.

Sample No. 29 was taken from a very poor pasture, much of which was covered with thin poor grass. A dressing of basic slag was advised to effect improvement and the application of this fertiliser resulted in a good development of white clover during the first season after application. It is of interest to know that in a portion of the arable field adjoining this pasture, where swedes were manured with superphosphate a normal crop was obtained, whereas where phosphates were omitted from the manurial dressing given the swedes were a very poor crop.

The two fields from which samples No. 30 and 31 were taken are of great interest. It will be noted from Table I. that both samples are very strongly acid—their lime requirements are the highest yet met with in the Bristol province. These two fields adjoin one another and are classed as pasture. When visited by the writer during August, 1922, No. 30 had no grass growing on it, but its surface was covered with hawkbit and dried out mosses,

and lichens, with a few stunted gorse bushes scattered over it. The herbage of No. 31 consisted of tufts of coarse, useless grass, rushes and gorse bushes. These are fields where it will be possible to test the effects of lime and phosphates under strongly acid conditions and in the presence of a thick mat of organic matter.

Sample No. 32, which is a coarse textured Greensand, is typical of the soils of many of the pastures found on this formation in Somerset and Wiltshire. The soils are generally very strongly acid and so far no data have been collected as to the effect of manures on these pastures. Wild white clover, however, has been observed to grow very freely on this type of soil, whilst many cases of arable crop failures on such soils in the area have been overcome by liming.

Samples No. 33 to 38 are examples of some of the alluvial soils of various origins taken from different districts of the province. No. 33 is probably mostly of New Red Sandstone origin. The sample was taken from a series of demonstration plots where different phosphatic fertilisers are being tested. It is of interest to note that at this centre, where the soil is acid and apparently poor in phosphates, bone flour, basic slag and Gafsa phosphate have all been effective—bone flour giving the best results.

On the meadows, from which sample No. 34 was taken, trials with superphosphate and sulphate of ammonia had been carried out by the farmer with practically no result. It should be noted that this is a case where superphosphate has not been effective where the soil is apparently poorly supplied with phosphates, but is also acid in reaction. A trial with basic slag has been recommended. The soil is probably largely of Silurian origin.

Sample No. 35 is from a Teme meadow where the grass is very coarse and rank and as a result of this stock do not eat it down. Slag has been applied to a portion of this field and where this has been done the cattle have grazed much more closely, the grasses are becoming finer and white clover is developing well.

The case in connection with which No. 36 sample was taken was very interesting. The sample was one of a number taken from some arable fields in which the farmers had often experienced crop failures. All samples were shown to contain large supplies of carbonate of lime and extremely low amounts of available phosphates.

The field adjoining that from which the sample was taken was very poor pasture and efforts were being made to improve it by applying basic slag. When examined during the first season after the application of basic slag, it was noted that the effect of the slag had been to produce a very dense growth of bird's foot trefoil and some white clovers.

Samples Nos. 37 and 38 were taken from a drift area in Herefordshire, where the soil is probably largely of Silurian and Old Red Sandstone origin. There is a fairly large area of this type of soil

around the Wye Valley in the west of Hereford. These soils are generally acid and where arable crops are grown it is generally essential to lime the land occasionally or certain crops fail.

At Centre No. 37 the field had been ploughed up during the war and was seeded down in 1919 or 1920. When inspected in 1922 the face of the pasture was extremely bare, and clovers were practically absent. A portion of the field was slagged in the autumn of 1922, and during the summer of 1923 the slagged area became covered with white and red clovers and afforded a large amount of keep.

Sample No. 38 is from a poor meadow which has been chosen for an experiment on the liming of grassland.

Summary of Results.

There are several points which arise from the soil data and foregoing discussion of the particular cases to which it appears desirable to draw attention. The most important of these are as under :—

1.—The analytical figures obtained for available phosphoric acid in the soils of the great majority of these poor pastures would be considered as being low and as indicating the probable need for phosphatic manuring (7). There is one case—No. 37—where the figure approaches that suggested by Wood and Berry as possibly being the upper limit at which phosphates may be expected to act, where basic slag has been found to be very effective.

At one centre—No. 30—where the available phosphoric acid would be regarded as satisfactory the pasture is useless. Here, however, the lime requirement is extremely high.

2.—There are a number of cases where the figure obtained for available potash would be considered low and where phosphatic fertilisers alone have effected marked improvements.

It has not been determined at these centres whether potassic manures would effect further improvement.

3.—The data furnish examples of soils containing large supplies of carbonate of lime, and of soils containing no carbonate of lime and which are acid in reaction, on which the pastures have been improved by the use of certain phosphatic fertilisers used alone—chiefly basic slag. On some of the acid soils lime used alone has failed to effect visible improvement of the herbage, whereas basic slag has effected great improvement. It should be noted, however, that the analytical data for these soils have also indicated poor supplies of available phosphates. It remains to be seen whether lime and phosphates would be more efficient in effecting improvement on some of these acid soils than phosphates alone.

Conclusions.

1.—From the foregoing limited amount of data it would appear that phosphatic fertilisers—generally basic slag—are efficient in

effecting improvement of the herbage of many of the poor pastures met with in the Bristol Province.

2.—Basic slag used alone will effect improvement of pastures on soils containing carbonate of lime and on acid soils, but cases of the latter have been met with where further trials are necessary before a general statement can be made as to whether basic slag alone will always be effective on such soils.

3.—This fertiliser has also proved effective on several soils containing apparently only poor supplies of available potash—but again there are certain light soils on which further experiments are required.

4.—Where lime alone has been applied to pastures on sour soils the herbage does not appear to have been materially improved.

Recommendations.

From the results already obtained and presented in this paper, one can reasonably recommend to farmers who are desirous of improving any poor pastures where the soil is not waterlogged or extremely light, to commence by making trials with dressings of the higher grade basic slags –30%to 38%—at the rate of 7 to 10 cwts. per acre on small areas of the pastures and to ensure that the area is adequately stocked, preferably with cattle and sheep, during the season following the application of the fertiliser. If finely ground mineral phosphates, such as Gafsa phosphate, are obtainable, these may be reasonably expected to react on soils where basic slag will effect improvement.

If this treatment is without effect, then it will be necessary to ascertain whether the case is one in which further treatment with lime or potash manures is likely to be necessary or whether it is a case such as quoted by Gilchrist (1) where no system of manuring is likely to give an economical return.

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THE BUFFING OF WILLOWS.

By H. P. Hutchinson.

The buffing of willows is an operation whereby, after a prolonged boiling in water, a mineral-brown colour is imparted to the wood of willow rods.

The process now in general commercial use is the outcome of a chance discovery made by a willow grower—John Marshall, of Sutton-on-Trent, Notts.—about the year 1860, who found that as a result of boiling, dried willows could be peeled at any period of the year. The colour which was developed in the wood of the peeled rods was believed to have been due to the action of urine in which the rods were, for some years, boiled, but at a later date it was ascertained that water produced the same effect.

Before the buffing process became generally known, peeling was only possible for short periods in the spring of the year, and all peeled rods were " white " in colour. At the present day " white " peeling, even by the aid of retardation methods, is only possible for a few weeks from the time of commencement of annual growth, owing to the rapid production of new wood. This layer forms as a " rind," which for a time does not possess permanent wood characters and is not in complete union with the outer layer of wood of the previous year. Being detachable from the latter it is spoken of by willow growers as " double skin " or " second skin." When the presence of this layer has become evident " white " peeling is stopped because such " double-skinned " rods split at the surfaces of union of the new wood with the old and because of discolorations which develop. The production of white rods was thus limited to the time during which the process could be carried out and any rods remaining unpeeled at the close of the peeling season were available for use only as " brown," *i.e.*, with the bark on, and at a low price.

The introduction of buffing had the economic effects

(1) of enabling a greater proportion of the willow crop to be peeled, since it permitted an extension of the operation through the year.

(2) of rendering possible a greater distribution of wages and better financial returns to the grower.

(3) of supplying basket makers with a new material suitable for use in the industry.

Although the operation may be performed continuously throughout the year, it is the practice amongst willow growers to cease buffing for the few weeks when peeling for " white " can be carried out and to return to buffing when the production of " white " is no longer possible.

A buffing plant consists of a boiling tank, rectangular in section, and suited in size to the quantity and size of the rods to be boiled in it. The smallest tanks will contain about half a ton of green rods ; those of the largest size have a capacity for over two tons. A tank 12 feet long, 3 feet wide and 4 feet deep is capable of holding 25 to 30 cwts. of rods and is of the size generally used. The material of which the tank is constructed usually consists of iron plates $\frac{1}{8}$—3-16th inches in thickness, welded or rivetted together, but tanks constructed of wood planks $2\frac{1}{2}$—3 inches in thickness bolted together and to a bottom iron plate are in use in the North of England. In this case the structure is made water-tight by the use of red lead at the joints.

The tank is set in brickwork in a similar way to that adopted in the case of a kitchen copper, but generally the bottom of the tank rests on an iron plate which forms the roof of the furnace, its purpose being to protect the tank bottom from the injury which would be caused by the direct flames of the fire. The furnace chamber is continued as a flue which connects with a chimney stack, as a direct straight run in the case of the smaller tanks, but in the case of many tanks of the larger size the flue is made to return in the brickwork of the setting so passing round the tank in the form of a low spiral before opening into the chimney. The object in the latter method of construction is to avoid waste of heat. In most cases the tank is provided with a ventilated roof placed sufficiently high to avoid inconvenience in handling the bundles of rods when filling, to keep out rain and to enable peeling to be performed by workers standing at the sides.

In filling the tank bundles of willows are placed lengthwise and covered with water. The bundles are packed together tightly by means of pressure applied on the upper layer, the object being to fill the tank with willows to its utmost capacity. Various devices are in use for securing the necessary pressure, one of the most efficient consisting of a stout pole made to act as a level of the Second Principle where the fulcrum is situated at the chimney end of the tank (being hooked to a firmly set ring) the power being applied in a downward direction at the other end of the pole, and the pressure on the rods transmitted through a T-shaped block of wood placed midway of the length of the tank. The rods are kept submerged by arranging for the handle end of the pole to be caught up by an iron hook set in the brickwork of the boiler. Many boilers are flanged in an inward direction on their upper edges, which. by

securing the ends of short planks placed transversely across the bundles, keeps the latter submerged. The top of the tank is provided with flat wooden covers, which serve to avoid loss of water as steam.

The rods are boiled continuously for from two to five hours. A tank filled in the afternoon can be brought to boiling point before the workers leave work. Attention to the fire is again needed (the furnace being damped down) later in the evening, after which boiling will be steadily maintained for several hours and the water will still be warm, and the fire capable of being revived, if necessary, in the morning.

Rods are peeled in the " warm " or " cold " condition. In the former method the peelers stand alongside the tanks and pick out from the water (kept warm by suitably controlling furnace heat). individual rods. The bark is easily removed by a dexterous twist of the wrist and fingers without further agency.

In some cases the peelers work at tables placed near the boilers and are supplied with rods by an attendant who removes the bundles from the boiler when required.

This system is satisfactory when the bundles are small and the rods short, but a large bundle of long rods becomes cold before it is finished, the peeling becoming progressively more difficult with decrease in temperature.

In cases where a grower does not possess a boiling tank, his crop of rods may be boiled by a boiler owner in the district and afterwards returned to be peeled at home. Such rods, being " cold," require the use of a " break " for bark removal. Peeling is then performed at a slower rate and the rods are frequently considerably damaged by being split, due to the pressure exerted by the " break."

The peeled rods are " sorted," *i.e.*, branched and damaged rods are removed, and afterwards " drafted," *i.e.*, " graded " according to length.

The graded rods are immediately exposed to sunlight, being supported in an inclined position against rails or fences. By this means the required intensity in depth of buff colour is produced and drying of the rods is effected. The time of exposure in the open air varies with the amount of sunlight obtainable and with the moisture content of the atmosphere. In some cases the rods may be ready for removal in two or three days, while in other cases three weeks' exposure may be necessary before the required depth and colour is reached.

Further drying is generally required, especially during the winter months, before the rods are in a proper condition for storage. They are placed on racks in a heated room where the heat is supplied by

stoves or by hot pipes connected with a boiler. When thoroughly dry the rods are securely tied in bundles, which are stored in dry quarters.

The investigations made at Long Ashton in the direction of ascertaining the reasons why boiling facilitates the removal of bark and why a permanent colour is induced in the underlying wood, have led to the following conclusions.

The effect of soaking dry willow rods in cold water for a sufficient length of time is to cause a swelling of the bark, due to its absorptive character, a release of cell products and a loss in the power of adherence of the bark to the wood, which is so far diminished as to permit of its ready removal. Boiling causes an increase in the rate at which penetration by water and the decomposition of cell products occur, the ease with which peeling can be performed being increased with the time during which the boiling is allowed to continue.

The colouring of the wood is primarily due to the presence of catechol, pyrogallol, and probably other similar aromatic compounds, which are formed as decomposition products of more complex tannin compounds present as natural products of cell activity in the rods. Such compounds exist in largest amount in the cells of the cortex, but are also present in certain cells of the wood. The effect of boiling is to cause rapid decomposition and the simpler compounds thereby formed are liberated from the containing cells and become distributed in the tissues of the wood.

Catechol and pyrogallol absorb oxygen, the absorption being accompanied by the formation of a brown coloration.

The oxygen supply present in the water in which the rods are boiled would explain the presence of the buff colour generally present in the wood when freshly peeled. The colour deepens on exposure to the air on account of further oxidation, which then takes place.

It is known that different varieties of willows give varied shades of buff even when under similar conditions. Generally varieties of *Salix triandra* buff readily—a three hours' boil and an air exposure for two or three days being found to be sufficient for the formation of a satisfactory colour. The rods of *Salix viminalis* (Osiers) give a paler buff with tendency to yellowing under the same treatment, while rods of *Salix purpurea* require longer boiling and generally several weeks exposure to light before the right colour is obtained. The different varieties of willows, even those varieties belonging to the same species, show differences in the degree of colour intensity in their buffed rods when grown on the same kind of soil, but great differences in colour are shown by the same variety when grown on different soils. For example, the variety, Black Maul (*Salix triandra*) produces a rich deep buff when grown on clay, but it is only by long continued boiling and air exposure that even a pale shade

of buff can be obtained when the variety is grown on peaty land.

Catechol and pyrogallol very readily absorb oxygen from the air when in alkaline media, with corresponding rapid formation of a dark-brown colour.

On this evidence it was thought probable that freshly boiled and peeled rods would darken in colour when treated with alkali. Experiment proved this to be the case and as a result of trials made with various strengths of different alkali solutions, it was ultimately found that lime water possessed sufficient alkalinity to give a colour similar to commercial buff to a boiled and peeled willow rod when placed in it for a few minutes. The buff colour appears almost instantly when the lime water is warm.

It was also found that the boiling process need not be continued for longer than one hour (in several cases half an hour's boiling was found to be sufficient) in order to obtain release of the colour-forming products from the cells of the bark and their impregnation of the underlying wood.

In the case of the variety, " Dicky Meadows," and of the other varieties of *Salix purpurea*—all of which buff slowly under present methods—the lime water treatment produces a darker buff than is produced in the case of any other variety of any species buffed under the existing system, but the colour formation can be controlled by the use of lime water of weaker strength and by boiling the rods for a shorter length of time.

In an industrial application of the method which had been described, it seems probable that a considerable reduction in the costs of production of buff rods could be made in that the length of time now found to be necessary to take in boiling and as outdoor exposure could be greatly shortened.

Since it has also been found that steam-heated willows produce a buff similar to that obtained by the boiling method, industrial development on these lines would probably lead to the substitution of steam for hot water. In such a case the present furnace and tank setting would be unnecessary as a low pressure boiler could be used to produce sufficient steam for the treatment of willows in the tank.

POT EXPERIMENTS ON THE MANURING OF FRUIT TREES.—III.

By T. Wallace.

During the past season the experiments with apple trees, gooseberry and black currant bushes and strawberry plants described in the Annual Reports for 1921, 1922, were continued, and two further experiments—one with raspberry plants and the other with apple trees—were commenced.

The experiment with raspberry plants was conducted along the same lines as the experiments on apple trees, gooseberry bushes, etc., with the object of studying the effects produced on the plants from the deficiencies of the various plant foods.

The new experiment with apple trees was commenced primarily to study the effects produced on the character of the foliage and on the growth of the trees by varying the ratios of certain of the elements of plant food contained in the complete nutrient solution originally used.

It was considered desirable to carry out such an experiment as it had been found in the previous work with apple trees that the trees fed with the complete natrient solution did not behave in an altogether satisfactory way.

Thus in previous years trees under this treatment had become affected with leaf scorch and in some cases they had shed the scorched foliage during the hot weather in July. Further, it had been shown that when potash was omitted from the complete nutrient solution and trees fed with this solution they had developed leaf scorch very severely, whereas when nitrogen was omitted from the complete nutrient solution and trees fed with this solution their foliage never became affected with scorch.

From these observations it appeared that a more satisfactory nutrient solution for this work might be obtained by narrowing the ratio $\frac{\text{Nitrogen}}{\text{Potash}}$ in the original complete nutrient solution.

It was also thought that in these cultures of coarse sand it might be advantageous to introduce a soluble silicate into the nutrient solution and it was decided to test this point.

The experiment, as conducted during the season, together with the results obtained, are described later in this paper.

The data collected from the various experiments during the season were similar in character to those described for the season 1922 and as the trees, bushes and plants undergoing the various treatments have behaved very similarly to what they did during the previous season it is not proposed to describe the observations made in detail, but to deal more especially with the more striking of the results obtained and with certain special features.

It is now becoming apparent from these experiments that the effects produced on the various plants by withholding any given element are similar though they may be more marked in some plants than in others.

As an example, the effects produced on the various plants by the withholding of phosphoric acid from the plant may be taken.

In every case where this treatment has been given the plants undergoing treatment have made excellent growth during the initial stages of the experiment—generally up to the middle of the first season. The foliage of the plants then commences to show characteristic bronze or purple tints, and the plants are defoliated prematurely. Cropping during the first or second season may not be greatly affected, but as time goes on all lateral buds become very weak, flower buds fail to break strongly and the fruits produced are very small in size and number. Finally, foliage is produced only near the terminal buds of the shoots. In the case of strawberry plants there is a tendency for the plants to form only single crowns.

The fact that some plants suffer more than others from a given deficiency is well illustrated by the behaviour of certain plants to potash starvation.

Apple trees, gooseberry bushes and raspberry plants make very poor growth from a very early stage when potash is omitted from the nutrient solution, whereas black currant bushes and strawberry plants do not appear to suffer to such an extent, although they actually show similar symptoms of the deficiency of the element as do the former group of plants.

The more important of the observations made in the experiments during the season are given in the following notes on the respective experiments.

Weather during 1923 *Season.*

The weather during the growing season was not very favourable for the growth of the trees and bushes. Up to the middle of March it was generally very wet and there was little sunshine. From the latter date until the end of May the temperature remained low, and although there was little rain the amount of sunshine was small. Cold east winds prevailed during this period and during the week

ending May 20th there were very severe frosts, accompanied by hailstorms, which did a certain amount of damage to the plants under experiment.

During the latter part of June and during July there were periods of hot, dry weather.

From August onwards the season was very wet and there were few days of bright sunshine. Hard frosts were experienced during the beginning of November.

Experiments on Apple Trees—Commenced 1921.

The foliage of the trees undergoing the various treatments showed the distinctive characters exhibited in previous seasons.

The trees in the series where nitrogen and phosphoric acid respectively were omitted and where only rain water was given, were later in blossoming and in coming into leaf than were those of the other series. The blossoms produced in these former series were also extremely weak.

In the series where potash treatment was omitted the trees showed leaf scorch early in the season. The trees of the following four series were defoliated prematurely—" rain water only," " nitrogen omitted," " phosphoric acid omitted," " magnesium omitted." There was much dying back of shoots noted near the end of the season on the trees in the " rain water only " series and in the " omission of phosphoric acid " series.

The shoot growth made during the season in all series was very poor, possibly because of the trees not having been pruned since spring, 1921, and it is proposed to cut back the shoots very hard this spring to attempt to induce new shoot growth in order to obtain further data on the types of shoots produced now that the trees are showing the starvation symptoms to a very marked extent.

Experiment on Gooseberry Bushes—Commenced 1922.

In this experiment observations were made during the season on general growth and foliage characters and cropping data were obtained.

At the end of season, 1922, two bushes per series were lifted for root examination and these were root pruned at that time and returned to their pots. These plants were turned out of their respective pots at the end of the present season when the root systems were again examined. This treatment is to be repeated in 1924.

As regards growth characters, types of foliage, order of defoliation of the plants of the various series, the observations made were similar to those made in 1922. It should be observed, however, that in the omission of phosphoric acid series there was practically no new shoot growth in 1923, whereas in 1922—the first season of the experiment—the shoot growth made in the early part of the season, presumably before the reserves of phosphoric acid in the plant were exhausted, was considerable. The plants in the following series were in much the worst condition at the end of the season—"rain water only," "nitrogen omitted," "phosphoric acid omitted."

The plants of the "potash omitted" series all showed marked leaf scorch during the greater part of the season and some of these plants are now in poor condition.

Cropping.

Cropping data for the season are presented in the following table:

TABLE I.

CROPPING OF GOOSEBERRY BUSHES.—SEASON 1923.

Treatment.	Complete Nutrient Solution.	Nitrogen omitted.	Potash omitted.	Phosphoric acid omitted.	Calcium omitted.	Magnesium omitted.	Rain-water only.
Number of bushes under treatment	10	10	10	10	10	10	10
Total number of fruits ..	256	65	329	390	181	298	125
Total weight of fruits (grammes)	565.9	74.2	774.1	533.8	489.9	887.7	147.2
Average weight per fruit (grammes)	2.18	1.14	2.35	1.37	2.70	2.98	1.18

As 1923 was the first season that a crop was taken from the plants the order of cropping shown in the table will not necessarily indicate which treatments will ultimately affect the cropping powers of the plants to the greatest extent. It is, however, of interest to note that the size of the fruits in the series "rain water only," "nitrogen omitted," and "phosphoric acid omitted," have been reduced below normal size even at this early stage.

Root Systems.

The examination of the root systems made by the root pruned bushes during 1923 was made on January 1st, 1924. The more important observations made were as follows:

Complete Nutrient Solution Series.—The root systems were large and consisted of plenty of strong coarse fibres well furnished with healthy fine fibres along their entire lengths.

Nitrogen Omitted.—The root systems were small. Both coarse and fine fibres were lacking and the fibres were comparatively thin. The fine fibres were yellow in colour.

Potash Omitted.—The root systems were of medium size. The coarse fibres appeared to be normal but the fine fibres were lacking in amount and were thinner than in the " complete nutrient " series.

Phosphoric Acid Omitted.—The root systems were small and both coarse and fine fibres were poorly developed. The colour of the fibres was a characteristic brown.

Calcium Omitted.—The two root systems were very different in size—one was large and the other small. Fine fibres were well developed on these roots. The roots appeared to have made more recent growth than in any other series.

Magnesium Omitted.—The root systems were large and there was plenty of both coarse and fine fibres. The roots, however, were brown in colour and careful examination showed that a large proportion of the fibres were dead at the tips.

Rain Water Only Series.—The root systems were similar in size and appearance to those in the series where nitrogen was omitted. There was a deficiency of coarse fibres and all the fibres were thin and had a starved appearance.

Experiment on Black Currant Bushes.—Commenced 1922.

The observations recorded in this experiment on the behaviour of the bushes during the season were similar to those made in the experiment on the gooseberry bushes.

The bushes behaved very much like the gooseberry bushes receiving the same treatments, those in the " rain water only " series and " nitrogen omitted " and " phosphoric acid omitted " series making very poor growth and being defoliated at a much earlier date than those in the other series.

The plants receiving " no potash " treatment showed very marked leaf scorch towards the end of the season and once more it was demonstrated that where plants are grown in pots which are not leached at intervals these plants develop leaf scorch more quickly than where leaching is carried out.

Some of the plants suffered severely during the season from aphides' attacks.

The cropping data for the plants are given in Table II.

TABLE II.

CROPPING OF BLACK CURRANT BUSHES.—SEASON 1923.

Treatment.	Complete Nutrient Solution.	Nitrogen omitted.	Potash omitted.	Phosphoric acid omitted.	Calcium omitted.	Magnesium omitted.	Rain-water only.
Number of bushes under treatment	10	10	10	10	10	10	10
Total number of fruits ..	828	113	644	381	1076	951	105
Total weight of fruits (grammes)	497.5	34.7	257.7	113.8	611.3	536.0	33.6
Average weight per fruit (grammes)	0.60	0.31	0.40	0.30	0.57	0.56	0.32

As in the experiment with the gooseberry plants. 1923, was the first season that crop weights were taken.

Here again it will be noted that the size of the fruits in the series "rain water only," "nitrogen omitted" and "phosphoric acid omitted," is much less than in the other series, whilst the actual crop weights obtained from the plants in these series have been already greatly affected by the treatments given.

The lateral buds on the shoots of the plants in these series were much smaller than those on the plants in the other series at the end of this season and doubtlessly very poor crops will be obtained from these plants in future seasons.

Root Systems.

The root systems made during 1923 by the bushes set aside for the purpose of studying the effects of the treatments on the development of the root systems were examined on January 1st, 1924. The various characters exhibited by the root systems of the different series were very similar to those shown by the root systems of the gooseberry bushes in the corresponding series and hence it is not necessary to describe these root systems in great detail. It will suffice to say that the root systems of the plants of the three series — "rain water only," "nitrogen omitted," "phosphoric acid omitted" —were much smaller than those of the plants in the other series; the fibre of those receiving "no phosphoric acid" treatment showed the characteristic yellow and brown colourations; the root systems of the "potash omitted" series were fairly well developed but the fine fibres were lacking to a certain extent; whilst the series receiving "no calcuim" treatment showed much recent growth of fibre and the series where magnesium was omitted showed evidence of root killing.

Experiment on Strawberry Plants.—Commenced 1921.

The plants in this experiment have shown similar growth characters to those exhibited in the two previous seasons.

At the beginning of the season the plants in the following series made the most rapid growth—" complete nutrient," " potash omitted," and " calcium omitted "—the plants in the series receiving " no magnesium " treatment were somewhat behind these whilst those in the series receiving " no nitrogen " and " no phosphoric acid " treatments respectively and those receiving " rain water only " were decidedly behind.

During the height of the growing season the plants in the three series receiving the " complete nutrient," " calcium omitted," and " magnesium omitted " treatments respectively were the largest plants ; those receiving the " potash omitted " treatment came next in order of growth, whilst the plants of the " no phosphoric acid " series were much smaller than these, and those of the " no nitrogen " series and " rain water only " series were smallest of all.

Towards the end of the growing season the plants in the " no potash " series again came forward in the order of growth among the series whilst the plants receiving the " no magnesium " treatment became very dwarfed as in previous seasons.

During the season the plants under the various treatments showed the characteristic tints which had been noted in previous years and which are described in the previous reports.

Cropping Data.

Cropping data have been collected for these plants for three seasons and are presented in Table III.

TABLE III.

CROPPING OF STRAWBERRY PLANTS.—SEASONS 1921-1923.

Season 1921.

Treatment.	Complete Nutrient Solution.	Nitrogen omitted.	Potash omitted.	Phosphoric acid omitted.	Calcium omitted.	Magnesium omitted.	Rain-water only.
Number of plants under treatment	10	8	10	9	10	10	10
Total number of fruits ..	131	49	76	83	90	119	51
Total weight of fruit (grammes)	513.8	191.4	279.2	356.1	358.8	483.4	170.6
Average weight of fruit per plant (grammes) ..	51.4	23.9	27.9	34.0	35.9	48.3	17.1
Average weight per fruit ..	3.92	3.91	3.67	4.29	3.99	4.06	3.34

Season 1922.

Treatment.	Complete Nutrient Solution.	Nitrogen omitted.	Potash omitted.	Phosphoric acid omitted.	Calcium omitted.	Magnesium omitted.	Rain-water only.
Number of plants under treatment	10	6	9	7	8	8	9
Total number of fruits	91	10	67	39	42	60	7
Total weight of fruit (grammes)	266.8	18.4	193.8	85.3	114.4	174.4	12.1
Average weight of fruit per plant (grammes) ..	29.6	3.1	21.5	12.2	14.3	21.8	1.1
Average weight per fruit ..	2.93	1.84	2.89	2.19	2.72	2.91	1.73

Season 1923.

Treatment.	Complete Nutrient Solution.	Nitrogen omitted.	Potash omitted.	Phosphoric acid omitted.	Calcium omitted.	Magnesium omitted.	Rain-water only.
Number of plants under treatment	10	5	9	6	8	8	8
Total number of fruits ..	110	3	87	32	136	92	9
Total weight of fruit (grammes)	471.0	9.7	345.4	116.6	554.3	321.3	24.6
Average weight of fruit per plant (grammes) ..	47.1	1.9	38.4	19.4	69.3	40.2	3.1
Average weight per fruit ..	4.28	3.23	3.97	3.64	4.08	3.49	2.73
TOTAL CROP FOR THREE SEASONS.							
Total number of fruits	332	62	230	154	268	271	67
Total weight of fruits (grammes)	1251.6	219.5	818.4	558.0	1027.5	979.1	207;3

Examination of the data relating to the total crops obtained shows that the smallest crops have been obtained in the three series where the plants have received the treatments " rain water only," " nitrogen omitted " and " phosphoric acid omitted " respectively. It should be noted in studying these data that during the third season only five plants remained alive in the " nitrogen omitted " series and six in the " phosphoric acid omitted " series.

Consideration of the data for each season shows very clearly that the omission of nitrogen and phosphoric acid respectively from the complete nutrient solution have affected the fruiting of the plants to a greater extent than any other treatment excepting the starvation treatment given where rain water only is supplied.

Experiments on Raspberry Plants.—Commenced 1923.

For this experiment ten plants—variety, Pyne's Royal—were selected for each treatment and these were potted up in silver sand contained in waxed 10in. pots in February, 1923.

Previous to potting, all the plants were root pruned and after potting the canes were cut down to within a few inches above the level of the sand in the pots.

A loose tarpaulin cover was placed over each pot to shade the sand. These could not be secured in permanent positions to protect the contents of the pots from rain owing to the growth of new shoots during the season and thus it was necessary to keep the pots under a glass shelter with open sides throughout the season.

Observations made.

The observations made during the season were confined to the growth characters shown by the plants.

The first observations were made on April 28th and the last on November 20th, by which time all the plants were practically defoliated, the only foliage remaining being affected by frost.

On April 28th it was noted that the plants in all the series were commencing growth and there were no noticeable differences observed from the various treatments on that day.

As early as May 13th, however, the plants receiving the treatments "nitrogen omitted," "potash omitted" and "rain water only" showed differences in their foliage from the plants receiving the complete nutrient solution, the leaves of the latter plants being at that time of a healthy green colour, whilst the leaves of those receiving the "no nitrogen" treatment were pale green in colour, those of the "no potash" series were dull green in colour and stunted and those of the "rain water only" series showed reddish tints.

From this date the more important features of the observations made were as under:

1. *Growth.*—From May 13th to the middle of July the plants receiving the "potash omitted" treatment made less growth than those of any other series. The plants remained stunted, the leaves were dull green in colour and developed patches of brown between the veins and showed a marked tendency to curl towards their under surfaces. The growth of the canes was very slender.

The growth of the plants in the series " nitrogen omitted " and " rain water only " were only slightly ahead of those of the " potash omitted " series during this period, but from July until the end of the season the " no potash " plants, although only making very poor growth, made slightly more growth than the plants of these series.

A further feature of note throughout the season was the poor growth made by the plants receiving the " calcium omitted " treatment. In previous experiments with apple trees, black currant bushes and strawberry plants, the plants receiving this treatment have made large growth—apples especially during the first season of the experiment and strawberries over the whole of an experiment which has been in progress for three years.

As in previous experiments with other plants, the plants receiving " no phosphoric acid " treatment made good growth during the season—being the first season of the experiment.

The plants of the " no magnesium " series were also behind those of the " complete nutrient " series in growth throughout the season.

Measurements of the length of canes made by the plants during the season were taken on December 21st, 1923. The data for these are given in Table IV.

TABLE IV.

GROWTH MEASUREMENTS OF RASPBERRY CANES.—SEASON 1923.

Treatment.	Complete Nutrient Solution.	Nitrogen omitted.	Potash omitted.	Phosphoric acid omitted.	Calcium omitted.	Magnesium omitted.	Rain water only.
Total number of plants per treatment	10	10	10	10	10	10	10
Total number of shoots ..	16	17	16	12	13	19	14
Total length of shoots (m.ms.)	10780	5300	6150	8006	6180	8500	3990
Average length of shoot growth per plant (m.ms)	1078.0	530.0	615.0	800.6	686.7	855.0	399.0

2. *Leaf Characters.*—The various treatments produced certain peculiarities in the foliage of the plants which, in general, were similar to those which the respective treatments have been noted to produce in experiments on other plants. These are described in detail below.

Complete Nutrient Solution Series.—The foliage of the plants in this series was normal in character, the leaflets being large, well developed and of a healthy green colour throughout the season until the time of dying down, when yellow tints were developed.

Nitrogen Omitted.—In this series the foliage was relatively scanty, the leaflets being smaller than those of the complete nutrient series. The colour of the leaflets from a very early date in the season was either yellowish green or almost white with occasional pink tints.

Potash Omitted.—Throughout the season the leaflets were small and dull green in colour and were much curled towards their under surfaces. Early in the season brown streaks appeared between the veins and from July onwards most of the leaflets developed brown marginal leaf scorch from an early stage in their development. This edge scorching was very marked by September. On September 24th it was noted that the foliage at the tips of the shoots was dying back on five of the plants.

Phosphoric Acid Omitted.—The foliage on these plants was similar to that on the plants receiving the complete nutrient solution until the beginning of September, when it commenced to develop bronzed tints which became more intense until leaf fall.

Calcium Omitted.—The foliage in this series had a somewhat unhealthy appearance throughout the season which suggested lack of vigour. The leaflets, without showing any very distinctive symptoms, were generally slightly paler in colour than were those of the series receiving the complete nutrient solution.

Magnesium Omitted.—The foliage was normal in appearance during the first half of the season, but from the end of July there was generally some yellowing of foliage observed, and during October some of the leaflets showed a definite blotching in their centres, whilst their margins remained normally green. This condition of the leaflets was not unlike that shown on the leaves of apple trees receiving similar treatment.

Rain Water Only.—The leaflets in this series were small and showed much red tinting throughout practically the whole of the season.

3. *Defoliation.*—The plants in four of the series—" rain water only," " nitrogen omitted," " phosphoric acid omitted," " magnesium omitted "—were defoliated before those of the remaining series. Some idea of the respective order in which the plants in the series became defoliated will be obtained from the following notes taken on September 30th and October 22nd, of the percentages of foliage which had fallen from the plants by these dates.

September 30th.—

Nitrogen omitted series—40% to 50% of the foliage had fallen.

Phosphoric acid omitted series—30% to 40% of the foliage had fallen.

Rain water only series—30 %to 40% of the foliage had fallen.

Magnesium omitted series—10% to 20% of the foliage had fallen.

October 22nd.—

Nitrogen omitted series—Approximately 60% of the foliage had fallen.

Rain water only series—Approximately 60% of the foliage had fallen.

Phosphoric acid omitted series—Approximately 50% of the foliage had fallen.

Magnesium omitted series—Approximately 30% of the foliage had fallen.

Other series—Less than 10% of the foliage had fallen.

Experiment on Apple Trees.—To determine the effect of altering the ratio $\frac{\text{Nitrogen}}{\text{Potash}}$ and of adding a soluble silicate to the complete nutrient solution previously used on the production of leaf scorch.

The reasons for carrying out this experiment are given at the commencement of this paper.

The variety used was Cox's Orange Pippin. The trees were planted in sand in 10in. pots on February 25th, 1921, and the method of procedure was as described for the previous experiments. Previous to planting all the trees used were root pruned according to the Stringfellow method and after planting all the shoots were pruned.

There were ten different treatments given, each treatment being given to a series consisting of five trees.

Details of the compositions of the various nutrient solutions used, together with the observations made during the season on leaf scorch and growth and foliage characters of the trees in the different series, are given below.

The series were lettered as follows and the respective nutrient solutions to be applied to these were labelled with the same letters—A, R, S, T, U, V, W, X, Y, Z.

Composition of the Nutrient Solutions.

Solution A.—This is the nutrient solution at present in use in all experiments as the "complete nutrient solution."

Sodium Nitrate	5.0 grammes
Potassium Nitrate	2.0 ,,
Di-potassium Mono Hydrogen Phosphate	1.0 ,,
Calcium Sulphate O H_2O	1.0 ,,
Magnesium Sulphate 7 H_2O	1.0 ,,
Sodium Chloride	1.0 ,,
Ferric Chloride	0.4 ,,
Rain Water	to 1 litre

Dilute 1 litre of solution with 9 litres of rain water for application.

Solution R.—As in solution A, but amount of nitrogen halved.

Solution S.—As in Solution A, but potassium substituted for sodium in equivalent amount.

Solution T.—As in Solution A, plus 1.0 gm. of sodium silicate.

Solution U.—As in Solution A, plus 2.0 gms. of sodium silicate.

Solution V.—As in Solution A, plus 5.0 gms. of sodium silicate.

Solution W.—As in Solution A, but amount of nitrogen halved and 1.0 gms. of sodium silicate added.

Solution X.—As in Solution A, but potassium substituted for sodium and 1.0 gms. of sodium silicate added.

Solution Y.—As in Solution A, but amount of nitrogen halved, potassium substituted for sodium and 1.0 gms. of sodium silicate added.

Solution Z.—As in Solution A, but nitrogen supply halved, potassium substituted for sodium and 5.0 gms. of sodium silicate added.

Observations on Growth Characters and Foliage.

The buds on the trees did not break much before May 13th, on which date it was noted that the leaves on some of the trees were fairly well advanced and that on the others they were still in a semi-developed condition. About that time the weather was very cold and there were several frosts, as a result of which some of the more forward foliage was damaged.

By the end of May the foliage on all the trees was well forward and looked similar in all the series. Immediately following this date the trees suffered to a certain extent from aphides' attacks, but the growth of most of the trees was not seriously affected by these. From quite an early date it was observed that the trees in all series in which the reduced nitrogen treatment and the various sodium silicate treatments were given were making less shoot growth than were those in Series A and at the end of the season the trees in these series were smaller than those in Series A. The leaves of the trees of the " half nitrogen " series were paler green in colour than were those in Series A throughout the season and showed a marked tendency to turn yellow during the season.

The silicate treatment on the other hand tended to produce leaves of a very dark green colour, especially in Series T, U, V, which leaves were of very attractive appearance during the early part of the season.

When the leaves of the trees in Series A were compared with those in Series S, X—receiving the same amount of nitrogen as in A, but extra potash—they appeared to have quite a bluish tint, the colour of those in Series S, X being a much purer green.

One further observation of interest made during the course of this experiment was that in Series S, X, Y where the solutions high in potash were used, some of the leaves of the trees developed brown patches in their centres, similar to those which were associated with deficiency of magnesium in the previous experiment on apple trees. It is intended to study this point further in 1924.

The order of defoliation was determined to a large extent by the amount of leaf scorch present on the trees, as the scorched foliage generally was shed prematurely.

The trees in all series were all practically defoliated by the last week in October

Observations on Leaf Scorch.

Some idea of the manner in whch the various treatments affected the production of leaf scorch on the trees will be gained from a consideration of the following notes taken at intervals throughout the season.

Date.	*Observations on Leaf Scorch.*
July 7 ..	None in any series.
„ 16 ..	Series T, U, V, slight scorching at tips of leaves. Remainder nil.
„ 22 ..	Series V, medium amount, Series T, U, slightly affected. Remainder nil.
„ 29 ..	Series V, fairly severe. Series T, U, A, slightly affected. Series W, one tree very slightly affected. Series R, S, X, Y, Z, nil.
Aug. 6 ..	Series V, all trees very badly affected. Series T, U, A, scorch medium in amount. Series W, very slightly affected. Series R, S, X, Y, Z, nil.
„ 11 ..	Series V, U, very badly affected. Series T, A, badly affected. Series W, very slight. Series R, S, X, Y, Z, nil.
Sept. 8 ..	Series T, U, V, very badly affected. Series A, badly affected. Series W, slightly affected. Series R, very slightly affected. Series Z, trace. Series S, X, Y, nil.
„ 16 ..	Series T. U. V, very badly affected. Series A, badly affected. Series R, W, slightly affected. Series X, trace. Series S, Y, Z, nil.

Sept. 24 .. Series A, T, U, V, very badly affected.
Series R, W, slightly affected.
Series *Z*, trace.
Series S, X, Y, nil.
,, 29 .. Series A, T, U, V, very badly affected.
Series R, W, slightly affected.
Series S, X, Y, *Z*, nil.

The observations made on leaf scorch after September 29th are not given above as shortly after that date a large amount of defoliation of certain of the trees took place—especially of those badly affected with leaf scorch—and hence if the condition of the foliage remaining in the different series after this date were described it would give an erroneous idea of the relative degrees of severity in the series.

The main points which are brought out by the above observations are as follows :

1.—The addition of sodium silicate in all the amounts used to the original complete nutrient Solution A produced an increased amount of leaf scorch over that produced in Series A—Solutions T, U, V—and where the highest amount was used, leaf scorch was most severe—Solution V.

2.—Where the amount of nitrogen in the nutrient solution was reduced to one half of the amount in Solution A, the development of leaf scorch was retarded and the amount reduced below that in Series A—Solution R.

Where this reduction of nitrogen was accompanied by the addition of sodium silicate, it was still effective in reducing the amount of leaf scorch developed below that in Series A—Solution W.

3.—Increasing the amount of potash in the original nutrient solution—Solution S—was entirely effective in preventing the development of leaf scorch throughout the season, being more efficient than the reduction of the nitrogen—Solution R. This increase of the potash content was also practically efficient in controlling leaf scorch in the presence of sodium silicate—Solution X.

THE APPLE BLOSSOM WEEVIL.

By Herbert W. Miles.

As a result of recent investigations it is apparent that local and isolated endeavours to control the Apple Blossom Weevil are not likely to yield a high degree of immunity and, since the pest is widespread and very destructive, relief should rather be sought in co-operative action. It is recommended, therefore, that growers' associations give this subject their earnest consideration with a view to encouraging in their districts the general adoption of a programme aiming at the destruction of the weevil. In order to carry out such a programme with chances of success familiarity with the habits and life history of the weevil, intimate knowledge of the control measures and their aims, and scrupulous care in carrying out these are points of paramount importance; and success will be directly proportionate to the thoroughness with which remedial treatment is conducted and the standard of hygiene maintained in the plantation.

Description.

(*a*) *The Adult* (Fig. I). The Apple Blossom Weevil, *Anthonomus pomorum, L.*, is a small snout beetle; that is, a beetle characterised by the possession of a long snout or trunk, the rostrum, on which are borne the head-feelers or antennæ. The insect is black, but overlaid with ashy grey pubescence and intermingling reddish and brownish scales, the effect being a more or less greyish tone with a lighter band forming a V-shaped mark towards the apex of the wing covers or elytra. The legs are darker than the body and the femora, or thighs possess teeth, those of the anterior pair being very stout The weevil measures from 4—5mm (2-5ths inches) in length.

(*b*) *The Egg* (Fig. II). The eggs vary in shape from spherical to ovoid; they are whitish in colour, and they measure about .6—.7mm. along their greatest length. The outer membrane of the egg is very delicate and easily ruptured.

(*c*) *The Larva* (Fig. III). The newly hatched larva is a soft, whitish, legless grubb, with a disproportionately large head; its body is sparesly covered with spines or bristles.

The mature larva is legless, dirty white in colour and wrinkled into numerous folds. It is sparsely clothed with bristles, which assist it in moving about. Its broadest girth is just behind the head,

i.e., in the thoracic region, from which point it gradually tapers off towards the caudal or tail region. There are three thoracic and nine body segments; the head is capable of partial withdrawal into the first thoracic segment. Owing to the fact that the mass of food contents of the alimentary system can be indistinctly seen through the outer skin, the larva often presents a brownish white, mottled appearance.

(*d*) *The Pupa* (Fig. IV). At the last moult of the larva the pupa is revealed. It is soft, fleshy and whitish, clothed with numerous bristles and possessing two stout caudal spines; the rostrum, antennæ, legs and wings are folded in close to the body and enveloped by a thin, transparent membrane. Later, as developmental changes go on, the membraneous wings turn smoky in colour, the eye spots become distinctly visible, and the mandibles, the tip of the rostrum, and the articulations of the limbs turn brown and, later, black. Immediately prior to the emergence of the weevil the tarsal claws and the edges of the thoracic region become darker.

Life History.

A brief account of the life history and habits of the weevil was given in the Annual Report for 1922, but at that time the illustrations in the insect stages and the phases of bud development of the trees were not available; since then, however, the detailed account of the work has been published (1) and some of the illustrations are reproduced here in amplification of the descriptive matter.

The weevils appear in the plantations in Spring, when the apple buds have reached the "green tip" or "delayed dormant" stage, as shown in Fig. V; this usually occurs in March. The insects are active, particularly in bright sunshine, when they may be found piercing the buds in the process of feeding. Shortly after their first appearance, probably owing to stimulation by feeding, mating takes place, and this is followed by a period of alternate feeding and sheltering, extending until the trees have so far developed that the "cluster bud" stage is reached, that is when the young flower buds, though clustered together, stand out from the young leaves. It is at this stage, which is seen in Fig. VI, that the female weevil bores holes into the young flower bud and lays her eggs in the stamens (Fig. II).

The young grubs feed first on the stamens and styles and later attack the petal bases and prevent the further development of the flower; the petals, instead of opening, turn brown, wither and dry and, retaining their position, act as a dome-shaped covering over the otherwise unprotected larva and pupa. This is the "capped blossom," which is first seen when the healthy buds are in the "blossom pink" stage or are just opening. The fully fed larva

pupates inside the capped blossom and in due course gives rise to the weevil which emerges and feeds for some weeks on the under surfaces of the leaves of apple, pear and plum, prior to seeking winter quarters in such sites as the rough bark of orchard and other trees in the vicinity, under the paper of old grease bands, in curled leaves either on or beneath the trees, and in cankered areas about the trees. The time for the completion of the life cycle from egg to adult varies, since it is directly dependent on the rapidity of development of the trees which, in turn, are influenced by weather conditions. Generally speaking, eggs may be found in mid-April, and young weevils may be taken during the last week of May.

Control.

Though the Apple Blossom Weevil has a number of natural enemies the most important, economically, is an Ichneumon fly, *Pimpla pomorum*, Ratz. This insect has been recorded (2) as parasitising the weevil to the extent of 27.4 per cent., and in France, where the capped blossom from 800 trees was collected, 250,000 parasites were reared, then liberated, and the effect of these in checking the pest was felt for some years. In young plantations such treatment might be adopted with advantage in this country.

Various control measures have been tried from time to time, but with inconstant results; one of these measures is jarring. It is based on the fact that when the tree or branch on which active weevils are located is struck with a padded mallet or other suitable striker the weevils fold their limbs close to the body and fall; many may be caught if tarred sheets are prepared for their reception. Since weather conditions influence to a considerable extent the activity of the weevil, this method is not likely to be invariably successful. Bright, warm, windless days appear to be most suitable but one or two trees should be tried each morning from the time the weevils first appear until the flower is past; when the weevil responds the treatment might be followed throughout the plantation.

Another method, which trials at Long Ashton indicate might be successfully employed, is trapping by means of bands of brown paper or sacking once or twice folded. These bands should be in position on the trunks near the crotch by the end of March and should be examined each morning and the weevils beneath brushed off into a bucket or tray containing paraffin. This treatment, too, should be continued until the flower is past or as long as good results are obtained; its success depends on the fact that numbers of weevils seek shelter between the times of their first appearance in spring and the time for egg-laying.

When the young weevils are fully fed, usually towards the end of June, they commence seeking shelter. It is advisable to furnish them with suitable sites in the form of bands placed on the trees

Fig. I.—Adult Weevils.

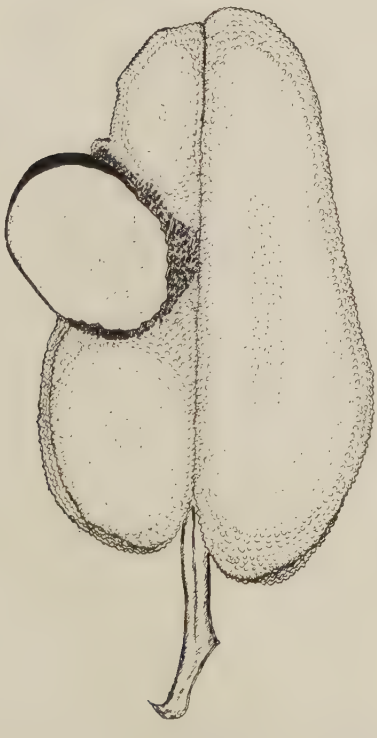

Fig. II.—Egg of *Anthonomus pomorum*, *in situ* in anther lobes of apple. × 60.

Fig. III.—1st instar larva of *Anthonomus pomorum*. Approx. × 50.

Fig. IV.—Lateral view, Pupa, *Anthonomus pomorum*.

Fig. V.—See text.

Fig. VI.—See text.

THE APPLE BLOSSOM WEEVIL (*Anthonomus pomorum*).

as before ; these should be in position by the middle of June and might be examined at intervals during August, September and October, the weevils found being removed and destroyed, and, finally, in the middle of February, these bands should be taken off and burnt. The maximum benefit will be yielded by this method only if the trees are kept free from mosses, lichens, loose bark and cankered regions ; it is advisable to scrape the trunks each winter and spray them with lime sulphur at least once per annum.

As previously indicated (3), the only spray which has yielded satisfactory results in destroying the weevil is an unstable paraffin emulsion applied to the sites where the weevil may be over-wintering. It is composed of :—

*Potash soft soap	0.5%
Paraffin	10%
Soft water	89.5%

This kills by contact ; it should be applied in late February or early March and constantly agitated while being used.

Direct control measures only attain their maximum efficiency when hygienic conditions prevail in fruit plantations. Growers should, therefore, make a point of observing strict cleanliness about plantations, particularly as regards crop residues and the upkeep of hedges.

The following programme of operations is suggested as offering the maximum immunity from the depredations of the Apple Blossom Weevil :

1.—Scraping the trunks of old orchard trees in February and applying the emulsion herein recommended.

2.—Spraying with Lime Sulphur 1—20, in the " delayed dormant" stage.

3.—Banding from the middle of March to the end of April.

4.—Collection of capped blossom during the first fortnight of May.

5.—Banding from mid-June onwards.

REFERENCES :

1. *Miles, H. W.* (1923) Ann. App. Biol. X, 3 and 4.
2. *Imms, A. D.* (1917) Ann. App. Biol. IV, 4.
3. *Annual Report*, Long Ashton Research Station. 1922.

*For this formula the following, in the light of recent work may be substituted.

Calcium Caseinate	1 lb.
Paraffin	10 gallons
Water	100 gallons

The effect is the same but the latter spray eliminates all complications due to hardness of water.

DATA ON THE LATERAL SPREAD OF THE ROOTS OF FRUIT TREES.*

By G. S. Peren.

The distance apart at which trees of the different fruits should be planted in the orchard is a subject of great importance to the commercial grower and one on which decisions must be greatly helped by a knowledge of the lateral spread of the roots of fruit trees. The policy of interplanting with "filler" trees or bush fruits, and the length of time which these may be allowed to remain without seriously competing with the permanent trees, should be guided by a knowledge of the rate of lateral spread and depth below ground level of the major portion of root systems. Unfortunately the importance of the last two factors is not appreciated to the same extent in this country as in most of the big fruit growing centres abroad, with serious results in many cases both to the growth of the trees and evenness in the size of their fruit.

In addition, this subject is extremely important at a Research Station, where it is often essential that trees under treatment shall be free from competition with the roots of surrounding trees.

For the above reasons it was therefore decided to make examinations of the roots of trees of the different orchard fruits as material became available, noting the length of the main roots and their depths below ground level.

The initial work was commenced in 1921. Although the material then available was not in all cases satisfactory, yet it was felt that it might prove of value in determining the best method of carrying out the work.

The results for that year, which were published in the Report of this Station for 1921, may be briefly summarised as follows :—

Example I.—Norwegian Cherry, standard tree, 15 years from bud. Lateral spread of roots approximately 30′.

Example II.—Apple, Bramley's Seedling, bush tree, 19 years old. Lateral spread of roots approximately 10′ 6″. Note : This tree had been transplanted when nine years old.

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Examples III.—Apple, King of the Pippins, bush tree, 19 years old. Spread of one root examined, 10′ 4″. An extremely poor tree and so figures are probably sub-normal for a tree of this age.

Example IV.—Apple, King of the Pippins, bush tree, 19 years of age. Spread of one root examined, 8′ (total length, 13′ 2″).

Examples V., VI. and VII.—Plums, Pond's Seedling, Victoria, Early Transparent Gage, bush trees, 16 years old. Lateral spread of roots examined approximately 9′ 6″, with one exception of 12′ 8″.

Example VIII.—Plum, Early Transparent Gage, bush tree, 16 years of age. Lateral spread of root examined 4′ 8″. A very poor tree, considerably below normal.

Example IX.—Broadleaved Paradise Stock, one year's growth after removal from parent stool. Length of longest root 22″.

Example X.—Apple, Stirling Castle, three bush trees, 4 years old (two years in site). Lengths of longest roots: Tree (*a*) 5′ 9″; (*b*) 4′ 9″; (*c*) 4′ 6″.

Example XI.—Apple, Allington Pippin, five bush trees, three years old (two years in site). Lengths of longest roots: Tree (*a*) 4′ 3″; (*b*) 4′ 8″; (*c*) 4′ 10″; (*d*) 5′ 3″; (*e*) 7′ 1″.

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The 1921 Report contains observations on the extent and character of the growth of the root systems of the aforementioned trees. Further data have been collected as opportunity offered and are summarised in the present article.

The method of examination adopted for 1922–23 has been to select at least the six largest roots and to follow them from their point of origin at the trunk to their apices, making at the same time notes on any variations in their depths below ground level.

The available materials consisted of apple trees of cider varieties, 16 years of age from the bud, which had been growing as standard trees in a grass orchard for the last 12 years.

This orchard has been heavily stocked for a great many years, and during the last four seasons has been used for raising pigs on the "out-of-doors" system.

The trees, which were approximately one-third the size of mature trees, were in excellent condition, and in this respect may be considered normal material.

The stocks concerned were "free" stocks, and exhibited to some extent the variations in type of growth which exist even among the strong "free" stocks.

Owing to lack of space available, detailed tables of the measurements taken are omitted. The measurements from the apices of

the roots in direct lines to the points where the roots arose from the trunks have been included in order to give a more accurate picture of the radius of root spread.

The depths of many lesser roots were taken at a distance of 3′ 6″ from the trunks, and with the exception of Example No. IV., the trunks of all the more important roots were traced and measured. Owing, however, to lack of space, the former are omitted, since few of them vary to any great extent from the larger roots, and only six typical large roots of each tree examined are shown in Fig. VII.

Tracing was not continued once a root was found to be striking downwards vertically on account of the large amount of labour required.

Example I.—Variety, Eggleton Styre. Length of roots :—

(1) Fig. 1A, actual length, 20′ 5″ ; apex of root from trunk, 18′. This root extended into a portion of the orchard which was ploughed in the Spring of 1922, and was cut off by the plough when 7/16″ in diameter. The detached portion could not be traced and so the figures given do not represent the full length of the root.

(2) Fig. 1A, actual length, 23′ 4″ ; apex of root from trunk, 20′ 8″.

(3) Fig. 1A, actual length 23′ 5″ ; apex of root from trunk, 22′ 6″.

This root when $\frac{1}{4}$ inch in diameter had been cut by the plough as in the case of (1).

(4) Fig. 1B, actual length, 19′ 2″ ; apex of root from trunk, 14′ 10″.

(5) Fig. 1B, actual length, 25′ 4$\frac{1}{2}$″ ; apex of root from trunk, 20′ 2″.

(6) Fig. 1B, actual length, 18′ 5″ ; apex of root from trunk, 15′ 1″.

Root struck vertically downwards and at a depth of 28″ was $\frac{1}{4}$ inch in diameter.

As will be seen from the diagrams, the trunks of the main roots are in this case contained within the top 20″ of soil. Detailed measurements were taken of all other important roots, but no marked variation was found.

Taking into account the fine terminal sections of the roots, which it is almost impossible to trace, the average radius of the root spread of this tree would appear to be approximately 20″.

Example II.—Variety, Sweet Alford. Length of roots :—

(1) Fig. 2A, actual length, 16′ 11″ ; apex of root from trunk, 15′ 11″. Root struck down vertically when $\frac{1}{8}$″ in diameter.

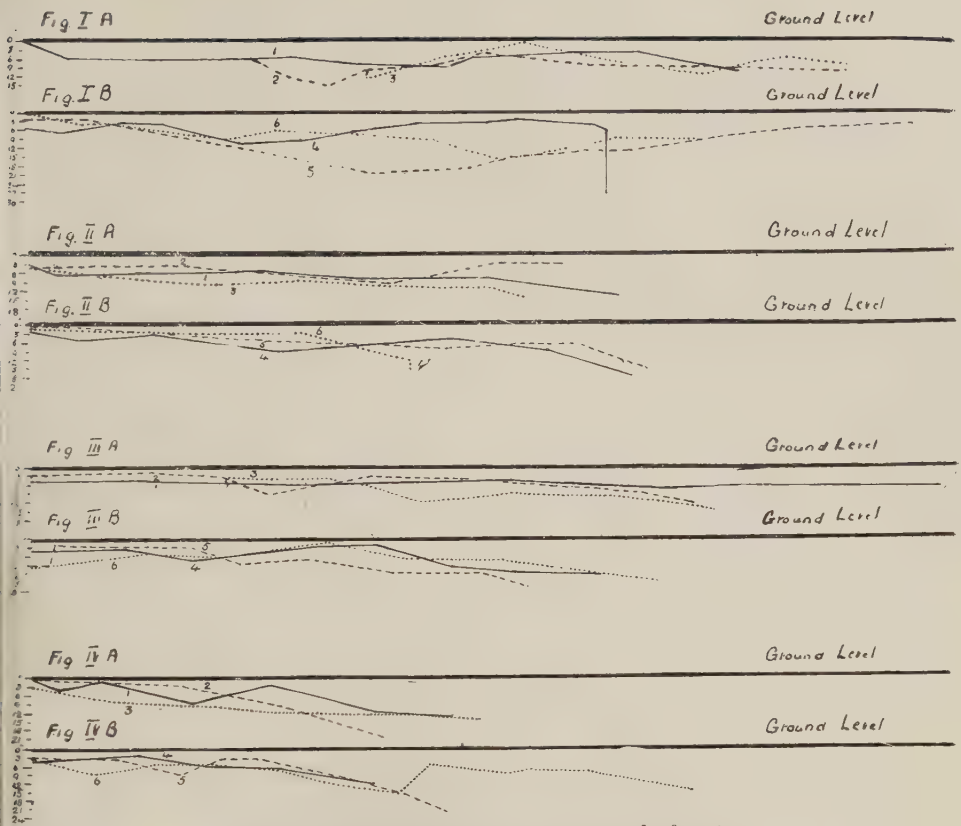

Fig. VII.—Showing depths below ground of roots.

Fig. VIII.—Pear leaves attacked by the blister fungus (*Taphrina bullata*) with accompanying infection of Scab (*Venturia pirina*).

(2) Fig. 2A, actual length, 15′ 3″; apex of root from trunk, 14′ 8″. This root when 3/16″ in diameter had been recently broken by pigs. Measurements could not be taken beyond this point.

(3) Fig. 2A, actual length, 14′ 6″; apex of root from trunk, 13′ 8″. Root struck downwards vertically when $\frac{1}{8}$″ in diameter.

(4) Fig. 2B, actual length 17′ 6″; apex of root from trunk 16′ 9″. Root struck downwards vertically when 3/16″ in diameter.

(5) Fig. 2B, actual length, 11′ 3″; apex of root from trunk, 10′ 4″. Generally speaking this tree was shallow rooted as the term is usually understood.

Only a few small roots struck downwards from under the tree. The average radius of root spread would appear to be about 15′.

Example III.—Variety, Royal Jersey. Length of roots :—

(1) Fig. 3A, actual length 25′ 10″; apex of root from trunk, 24′ 4″.

(2) Fig. 3A, actual length 19′ $\frac{1}{2}$″; apex of root from trunk, 17′ 8″. Root struck downwards vertically when 3/16″ in diameter.

(3) Fig. 3A, actual length, 20′ $\frac{1}{2}$″; apex of root from trunk, 12′ 8″. Root struck downwards vertically when 3/16″ in diameter.

(4) Fig. 3B, actual length, 17′ 11″; apex of root from trunk, 15′ 5″. Root struck downwards vertically when $\frac{1}{8}$″ in diameter.

(5) Fig. 3B, actual length, 14′ 9″; apex of root from trunk, 13′ 11″. Root struck downwards vertically when 3/16″ in diameter.

(6) Fig. 3B, actual length, 16′ 3$\frac{1}{2}$″; apex of root from trunk, 15′ 1″.

It will be seen by reference to Fig. 3A and Fig. 3B that this stock was extremely surface rooting, some of the roots running for considerable distances within a few inches of the surface and well within the zone of the roots of the grass.

The absence of roots arising immediately under the tree was most marked.

The radius of root spread is again about 15′.

Example IV.—Variety, Knotted Kernel. Length of roots :—

(1) Fig. 4A, actual length, 11′ 10″ 0 apex of root from trunk, 10′ 3″. Root struck downwards vertically $\frac{1}{8}$″ in diameter.

(2) Fig. 4A, actual length, 10′ 1″ ; apex of root from trunk, 8′ 6″. Root struck downwards vertically when $\frac{1}{4}$″ in diameter.

(3) Fig. 4B, actual length, 13′ 8$\frac{1}{2}$″ ; apex of root from trunk, 11′ 9″.

(4) Fig. 4B, actual length, 9′ 7$\frac{1}{2}$″ ; apex of root from trunk, 9′ 3″. Root struck downwards vertically when $\frac{1}{4}$″ in diameter.

(5) Fig. 4B, actual length, 11′ 6$\frac{1}{2}$″ ; apex of root from trunk, 10′ 11″. Root struck downwards vertically when 1/6″ in diameter.

(6) Fig. 4B, actual length, 19′ 3″ ; apex of root from trunk, 19′.

The stock of this example was distinctly " fangy " and deeper rooting than the other three examined. A number of roots of equal size to those traced, struck down from the trunk at an almost vertical angle and could not be followed owing to the large amount of labour necessary.

The " break " of the new roots after planting in the orchard was quite distinct, large numbers of strong roots having arisen from the ends of the original " fangy " roots which had necessarily been heavily pruned when the tree was lifted in the nursery. This dissipation of the growth of the root system appeared to account for the shorter average root in this example and the roots, which had arisen on the inner sides of the old " fangs," tended to continue downwards at steep angles as already stated.

It may be mentioned as a point of interest, that this variety, which makes a strong and very upright tree, has the reputation amongst nursery hands of inducing very deep-rooting by the stock. Being a cider variety, it is, incidentally, always " worked " on untyped " free " stocks.

In this example probably not more than 50 per cent. of the large roots were contained in the first 20″ of soil.

The radius of root spread is in this case only some 10′.

A noteworthy feature of the observations here recorded, as in those of 1921, has been the frequency of occurrence of roots which, after pursuing a more or less horizontal course for some distance, suddenly dip in a practically vertical direction and penetrate to a considerable depth. Such cases have been noted in root systems

of widely differing ages, some indeed only three years old. The character of the soil at the point where the abrupt change in direction occurs presents no obvious feature to account for this behaviour, and it may be stated with certainty that it is not associated with the striking of any actual cleft or lighter vein. Appearances suggest that these downward striking roots are the true terminals of extension growths of the root system. As terminals they seem to be positively geotropic and the vertical habit results, and on reaching depths at which conditions for free root growth are less favourable, their rate of growth is checked and the laterals immediately behind, which are growing in a more or less horizontal direction, are accordingly stimulated to greater activity and become in effect leaders, for the time being continuing their horizontal course. In turn the latter may ultimately strike downwards and in this way a succession of extension growth in either direction is produced, the horizontally placed being usually the more vigorous by reason of the more favourable conditions. What determines the sudden change from the horizontal to the vertical course can only be surmised on the evidence at present available ; it may, from indications observed, synchronise with the beginning or end of each growing season.

It is interesting to note that under the prevailing local conditions the roots of " free " stocks frequently penetrated the upper 6″ of soil which contained a mass of grass roots. The grass, as already previously mentioned, has always been heavily stocked.

Summary.

From the results of even the relatively small number of root systems examined during the last two years it is evident that in the case of healthy material there must be considerable overlapping of the root systems of permanent trees at the distances at which a large percentage of both bush and standard trees are planted in this country. While in the absence of definite evidence showing the extent of the effect of such over-lapping no quantitative statement can be made, it is hardly to be doubted that the check to growth must in many cases be severe.

The cherry, plums, and apples on Paradise stocks examined in 1921, and with one exception, the apples on " free " stocks examined in 1922, appear to confine the major portion of their root systems to at least the first two feet of soil. This may be due in part to the humid climate of this locality and to the presence of a heavy, poorly aerated subsoil, but other investigations already cited have found that the feeding roots of the bulk of apple trees are much nearer to the surface than has been generally supposed..

When the observations recorded in the two preceding paragraphs are considered in conjunction, some idea may be gained of the

congestion of feeding roots which must exist where an orchard of large trees is planted up with soft fruit and the severe competition which must follow when " filler " trees are left in too long.

Considerably more data must be collected before the economic aspect of these observations can be profitably discussed. It is intended to examine during the coming year a number of vigorous young trees on Paradise root stocks.

PROGRESS REPORT ON BIG BUD AND REVERSION OF BLACK CURRANTS.

By A. H. Lees.

In the winter of 1920 545 black currant bushes were planted at Long Ashton for the purpose of investigating Big Bud and Reversion diseases in the field.

Sufficient time has now elapsed to get some indication of the increase or otherwise of these diseases. The writer, however, would very urgently point out that general conclusions must not and cannot yet be drawn since the plantation is as yet relatively young and its subsequent behaviour may not be similar to its behaviour so far.

The plantation consists of four varieties according to Hatton's chief groups: Victoria, Boskoop, French and Baldwin. The varieties at Long Ashton are Edina, 115 bushes; Boskoop Giant, 123; Seabrook's Black, 134; Baldwin (Strain I), 57; Baldwin (Strain II), 118. Strain I was obtained from Herefordshire; Strain II from Kent.

Each winter every bush has been marked for presence of Big Bud and each summer for the presence of Reversion. There have thus been so far four markings for the former and three for the latter. The results for numbers are given in Table I., and for percentages in Table II.

Table I.

Variety.	Reverts. Year.			Revert Recovries. Year.		New Reverts. Year.		Big Bud. Year.				Big Bud Recoveries. Year.			New Big Buds. Year.		
	1	2	3	2	3	2	3	1	2	3	4	2	3	4	2	3	4
Edina ..	23	26	25	1	1	4	0	81	21	30	40	65	11	7	5	20	17
Boskoop Gian ..	5	6	7	0	0	1	1	2	1	3	8	1	0	0	0	2	5
Seabrook's Black ..	6	8	10	1	0	3	2	0	0	0	5	0	0	0	0	0	5
Baldwin I	0	0	1	0	0	0	1	0	1	2	12	0	1	2	1	2	12
Baldwin II	4	7	7	0	0	3	0	2	3	9	34	1	0	1	2	6	26
Total ..	38	47	50	2	1	11	4	85	26	44	99	67	12	10	8	30	65

TABLE II.

Variety.	New Reverts Year. 1	2	3	Total Big Budded. Year. 1	2	3	4	New Big Budded. Year. 1	2	3	4
	%	%	%	%	%	%	%	%	%	%	%
Edina ..	20	3.5	0	70	18	26	35	70	4.3	17.4	14.8
Boskoop Giant	4.1	.8	.8	1.6	.8	2.4	6.4	1.6	0	1.6	4.0
Seabrook's Black ..	4.5	2.2	1.5	0	0	0	3.7	0	0	0	3.7
Baldwin I	0	0	1.8	0	1.8	3.6	21	0	1.8	3.6	21
Baldwin II	3.4	2.5	0	1.7	2.5	7.6	29	1.7	1.7	5.1	22
TOTAL ..	6.9	2	.7	15.6	4.8	8.1	18.2	15.6	1.5	5.5	12

In Table I., Column 2, contains the total number of reverted bushes in each year, Column 3 the number recovering each year, Column 4 the number of new reverts (not counting old ones therefore) each year. Column 5 contains total big-budded bushes for each year, Column 6 the recoveries, and Column 7 the new big-budded bushes each year.

These results are brought into truer perspective in Table II., where the more important figures are expressed in percentages. Considering Reversion first, this table shows that the varieties were very differently infected when obtained from the raiser. Thus Edinas contained 20 per cent. reverts the first summer; Boskoop, Seabrook and Baldwin II, about 4 per cent.; and Baldwin I, 0 per cent. It is clear, therefore, that to the grower the source from which he obtains his bushes is of prime importance. In the second year the number of fresh reverts shows a considerable drop, the totals falling from 6.9 per cent. to 2 per cent., and the individual varieties falling where possible, in varying degrees. The third year shows a further drop for the totals to .7 per cent., only one variety showing a rise, representing actually one bush only. There has, therefore, been a continuous drop in fresh infections, if fresh infections they really are, even the highly infected Edinas showing no new case in the third year.

In the ordinary course of events reverted bushes should be removed from a plantation and it is for this reason that percentage figures for new cases and not for totals present have been considered. In this plantation this roguing has not been done in order to give a source of infection if possible. Despite this the new infections have decreased from year to year and there is no evidence to show that old bushes act as sources of infection.

If proper roguing had taken place and one were to imagine an acre of such bushes set 6ft. by 6ft. then, in the first year out of

1,210 bushes 83 bushes would have been revert, in the second year 24, and in the third year only 8. The plantation is, however, as yet young, and there is no guarantee that its future behaviour will be the same as its past.

Considering now the figures for Big Bud infection, Edinas arrived from the raiser with 70 per cent. of the bushes infected ; Boskoop and Baldwin II, with about 2 per cent., and Seabrook's Black and Baldwin I, with 0 per cent.

The Edinas were, of course, not fit to plant commercially and should, in ordinary commercial practice, have been returned to the vendor. In this case, however, it appeared a good opportunity for testing treatment. Every big bud was most carefully removed with the result that in the second winter only 18 per cent. instead of 70 per cent. were infected and those only very lightly. The 18 per cent. second year infects were not confined to bushes infected in the first year, but were equally distributed over all the bushes of the variety whether originally infected or free. No further big buds were removed except in the ordinary course of pruning and the variety showed further increases in numbers of infected bushes in the third and fourth years.

Boskoop Giant has shown a slow increase of infection and thus, up to the present, has shown itself somewhat resistant.

Seabrook's Black has justified its introducer's claim for high resistance to Big Bud. No claim for immunity has ever been advanced by its introducer and the distinction between the two terms should be clearly recognised.

So far all the big-budded Seabrooks are reverts, though the exact connection between the two diseases is not yet clear. Considering this variety alone one might say that only reverted bushes get Big Bud, but in other varieties this is not the case. Both Baldwin strains started with a low percentage infection of Big Bud. By the fourth year, however, they are relatively high. It is clear that the green budded varieties, Edina and Baldwin, are far more susceptible than the red budded Boskoop and Seabrook. This fact is, of course, already known, but the figures in Table II. serve as additional evidence.

The totals for big-budded bushes show a considerable drop in the second year, due to removal of big buds, followed by a rise up to the fourth year when the first year's figure is somewhat exceeded. Practically all these big-budded bushes are only slightly affected and such bushes, where not reverted, seem to bear a normal crop. Thus so far the only crop-inhibiting factor that appears to be acting is Reversion.

Conclusions.

Up to the present, and without prejudice to the future of the plantation, the following conclusions may be drawn from this investigation :—

As regards Reversion :—

(1) The number of new infections has decreased each year.

(2) There is no evidence to show that reverted bushes act as sources of infection.

As regards Big Bud :—

(3) A rigorous removal of Big Buds in the winter considerably reduces the infection the following year, even with bad cases.

(4) Mildly attacked bushes show no appreciable reduction of crop.

THE STRUCTURE OF REVERTED BLACK CURRANTS.

By Winifred F. F. Ridler.

In the Annals of Applied Biology, Vol. IX., 1922, Mr. A. H. Lees described a method for identifying cases of Reversion in Black Currants by means of certain morphological characteristics on the leaf, and the nature of the leaf margin the number of sub-main veins running from the mid-rib to points in the margin, and the number of margin points being numerically fewer in reverted leaves than in normal ones.

The object of the present investigation was to ascertain if there were any anatomical differences between reverted and normal plants, and if so, whether such differences could be correlated with the morphological evidences of the disease.

For this purpose a large number of normal and reverted plants grown at Long Ashton, namely, Edina, Seabrook's Black, Boskoop Giant and Baldwin, though Boskoop Giant was examined in most detail. Sections were cut from every part of the plant.

In the root, stem, leaf stalk, leaf, inflorescence stalk, and flower stalk the differences are of the same type in all. In all cases the main differences seem to lie in the tissues of the wood and bast, the structure of the cortex and pith being apparently the same in both normal and reverted plants. The wood cells throughout reverted plants are smaller than in the normal, while the cells between them (medullary ray cells) are larger in the revert than in the normal. This is shown in the following table of measurements, the figures given being the diameter of the cells in μ.

	Normal.		Revert.	
	Wood.	Med. Ray Cells.	Wood.	Med. Ray Cells.
Root	7—50μ	3·5—9μ	5—45μ	3·5—14μ
Stem	18—36μ	—	14·5—30μ	—
Petiole	20—25μ	3·5—9μ	15—20μ	3·5—10μ
Leaf	15—45μ	2·5—6μ	12—35μ	3·5—7·5μ
Peduncle	3·5—18μ	—	3·5—10·5μ	—

The area of the woody tissue, therefore, as compared with the area of the medullary ray tissue, is smaller in the reverted plant than in the normal. The arrangement of the cells in these two tissues is also less regular in the revert, and the cells themselves have less definite contours. There is one other difference which is

shown to the greatest extent in the leaf-stalk. In reverted plants a gummy substance is produced which may completely block some of the wood cells or entirely destroy them. This gum may also occur in certain cells of the bast. It is produced also in normal plants, but not to so large an extent.

The fruits of black currant plants suffering from Reversion, either do not form at all, the flowers themselves shrivelling up and dropping off, or the fruits may begin to form, in which case, development is soon arrested and the half-formed berries shrivel and fall.

Sections through a normal unripe fruit show a large well-developed and profusely branched conducting system. The ovary is large and well-developed and the ovules are normal and healthy, showing reproductive nuclei. In the reverted plant where formation of the fruit has begun, the internal condition as shown by sections, is very different. The conducting system is reduced and not so profusely branched. The ovary is small and poorly developed, and the ovules reduced in size and hypertrophied, no reproductive nuclei being formed.

In some cases, where the fruit has not even begun to form, and the whole flower has dropped off, sections show that the conducting system is still more reduced and may even be absent altogether. An enormous amount of the gummy substance described as occurring in the petiole, may be produced at the base of the ovary, in some cases completely blocking all the tissues. The ovary is very reduced in size, and the ovules are aborted. The stamens are hypertrophied and the pollen grains arrested in development.

Briefly, the main differences showing to a greater or lesser extent all through the plant are, a reduction in the amount of wood, and a consequent increase in medullary ray tissue, coupled with a tendency to produce more gum in the reverted plant than in the normal.

On the whole it is very difficult to correlate the morphological evidences of the disease with any of the anatomical differences observed, as the latter seem quite inadequate to account for the comparatively large morphological effect.

EGG KILLING WASHES.*

By A. H. Lees.

The experiments described below are a continuation of work done during the Winter of 1922 and published in the Annual Report for 1923. This work showed that certain substances were capable of reducing the hatch of Aphis pomi (Permanent Apple Aphis) to under 1% against control hatches of 2.4, 7.2, 17.5 and 25.3. While the figures for hatching of controls were too variable to be satisfactory there was clear evidence that in these experiments lime-sulphur and some coal tar products had very marked killing action. The trials were, therefore, continued in the winter of 1923 and a special attempt was made to eliminate some of the probable sources of error.

Procedure.

The eggs selected for the trials were those of the Permanent Apple Aphis, A. pomi. These eggs can be obtained generally in large quantities and the young trees, mostly maidens or two-year-olds were grown in pots. This method enabled the trials to be carried out under conditions approaching as far as possible to natural conditions in the field.

Each fluid to be tested was sprayed, not painted as in 1922, on to a single long twig covered with eggs. Untreated twigs were left occasionally as checks. Care was taken that no spray fluid reached any neighbouring twigs on a tree that were to be tested with a different fluid.

In 1922 some of the controls and treated portions showed an unexpectedly low hatch and it appeared probable that this was due to the fact that such eggs were exposed to a laboratory temperature for two or three hours. It has been shown that aphis eggs, if subjected to room temperature in winter are very apt to die. To avoid this possibility, therefore, the trees were sprayed outside in fine weather or in a cold greenhouse in wet weather. They were not exposed to rain and weather until the spray fluid was dry, but after this was accomplished they were placed in an unsheltered position.

As soon as hatching began the trees were removed inside and laid over oiled paper. The young larvæ on emerging from the

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egg seem to find considerable difficulty in preserving a foothold and usually fall on to the paper. In this position they can be counted at leisure. After hatching was finished and all counts made the twigs were cut into sections and the empty egg shells and unhatched eggs separated by hot caustic soda. The number for each treatment was then estimated by counting six separate aliquot portions.

Results.

Controls.—The percentage of hatch for the six controls used during the whole experiment were 15, 26, 26, 30, 46, 43, or an average figure of 30.5. These figures are much higher than those obtained in 1922 and point to the probability of the experiment being done under more natural conditions. No doubt a certain number of larvæ were lost before the trees were removed inside for counting. It was unfortunately impossible to find sufficient room under cover and under proper conditions to make the move early enough to preclude this possibility.

For convenience of consideration the various substances tried may be divided into a few groups.

The first group consists of various sulphur bodies of which lime-sulphur is the most important.

TABLE I.

SULPHUR GROUP.

% hatch.

Lime Sulphur	Alone.		With ·2% Calcium caseinate.	
	Applied Feb. 20th	Applied Mar. 19th	Applied Feb. 20th	Applied Mar. 19th
1 in 15	7	7	·07	·55
1 in 20	3	9	·5	·7
1 in 30	12	0	·55	·9
1 in 60	20		20·0	
Sulphur fumigation	26			
Sulphaqua 1 in 500 ..	8			
	13			
1 in 1,000 ..	43			
Hypo 5%	29			
Hypo and HCl ..	18			
Sulphur paste ..	15			

The lowest number of eggs used in the lime-sulphur treatments was 246, the highest 4,666 and the average 2,059.

The figures for lime-sulphur applied alone at all strengths and times are comparatively high. It may be taken that unless a fluid gives a percentage hatch of below one it has but little value for commercial purposes. The rate of multiplication of aphids is

so high that any figure higher than one would give in practice but a poor control. In the 1922 results figures below 1% hatch were obtained but the 1923 figures are more in accord with the frequent unreliability of lime-sulphur for egg killing purposes which has been the experience of commercial growers. There are two possible reasons for the discrepancy between the 1922 and 1923 figures. The first is that the 1923 controls gave a higher hatching figure, which suggests that in 1922 there may have been some other anti-hatch factor present beside the wash used. The second and probably more important reason is the different method of application. In 1922 the lime-sulphur was brushed on, in 1923 it was sprayed on. Lime-sulphur has rather poor wetting powers and the extra contact made by brushing over spraying may serve to explain the difference obtained in the two years. That this explanation is probably correct is indicated by the figures given for the various strengths of lime-sulphur when used with the addition of .2% Calcium caseinate. Calcium caseinate increases the spreading power and probably the wetting power and a very marked change in the percentage hatch figures are shown.

With the exception of the strength 1 in 60 all strengths tried show a hatch of under 1%. On the whole the higher strengths show slight superiority and the same applies to the earlier date. Those differences though consistent are not of such magnitude that undue stress should be laid on them. The chief point brought out is the very large difference made by the additions of Calcium caseinate. It would thus appear that a higher strength than 1 in 30 is unnecessary and should this result be confirmed by further trials it would appear that lime-sulphur could be used as a cheap and reliable aphis egg killing wash for winter work.

The lower part of Table I shows the effect of various other sulphur containing fluids. Fumigation by sulphur vapour had no appreciable effect. Sulphaqua, a proprietary body giving off sulphur dioxide and finely divided sulphur, had a slight effect at the higher strength and so possibly had sulphur paste and hypo and hydrochloric acid. On the whole, however, there was nothing to indicate that either finely divided sulphur of sulphur dioxide had any appreciable effect. This fact seems to suggest therefore that the action of lime-sulphur must be looked for in its polysulphide content.

The lowest number of eggs used per treatment was 120, the highest 5,533, and the average 1,919.

The original idea in testing mixtures of caustic soda and nicotine was that the action of the soda might prepare the way for the entry of the nicotine. It was not probable that either substance by itself was likely to be effective but the combination might. The 1922 results were inconclusive but suggested that there might be some action.

TABLE II.

NICOTINE SODA GROUP.

% hatch.

Caustic Soda. %	Nicotine. %	Feb. 20th.	Mar. 10th.
2	·05	3	0
2	·025	4	·05
2	·012	22	
1	·1		0
1	·05	17	
1	·025	21	·16
1	·012		·54
	·05	22	11·0
	·025		27·0
	·012	44	13·0

Table II shows that for the February date and for most of the strengths tried the mixtures were useless. Two per cent. soda combined with .05% and .025% of nicotine did, however, considerably reduce the hatch. For the March date all combinations of soda and nicotine caused marked reduction of hatch bringing it below 1%. In all these cases a slight damage to the terminal bud was caused owing to the fact that it was already swelling. No permanent damage was done however. Nicotine by itself without soda proved ineffective at all strengths though slightly more killing than when tried in February. The addition of caustic soda considerably increased killing power, as may be seen by comparison of different strengths of nicotine in the February treatments. Thus for strength .012 nicotine no soda gave 44% hatch, 2% gave 22%. For .025% nicotine 1% soda gave 2.1% hatch, 2% gave 4% hatch. For .05% nicotine 1% soda gave 17% hatch, 2% soda gave 3% hatch. From these facts it is clear that caustic soda nicotine might have a commercial use under certain circumstances. Thus, when an orchard is especially overgrown with epiphytes or mussel scale has to be dealt with, by delaying the spraying as late as possible and adding .025% of nicotine an ordinary caustic soda spraying might be made very much more effective against insect eggs.

TABLE III.

COAL TAR GROUP.

% hatch.

% Strength.	10	7	5	4	$3\frac{1}{2}$	$2\frac{1}{2}$	2	1
Substance								
A	1·4	7		52				23
B	5	6		15				22
C	5	5		22				15
D	·06	·3		8				38
E	6	5		27				31
F				30			31	49
G			·39		·9	·38		
H	18		26			10		

The lowest number of eggs used per treatment was 230, the highest 4,850 and the average 1,361.

In the above Table A—D are portions of a gas works distillate boiling between certain temperatures. These portions were combined with soap to form emulsions and tested at the strengths shown in the table. The only fractions showing any marked killing power are 10% of A, and 10% and 7% of D. It is hoped to follow up the indications given by these figures in future trials.

E and F were proprietory preparations and the figures given call for no comment.

G was an artificial product made up from a well known coal tar derivative and gave very satisfactory results. No injury resulted to the plant from the use of G.

H is another tar derivative, which not only gave a very high percentage hatch, but also killed all the treated plants.

It is clear from these figures that coal tar derivatives derived from gas works products only give very variable results. Many substances have no useful action, some are directly dangerous and some appear to be very useful. The trials are yet at too early a stage to allow of any definite conclusions being drawn, but the fact that one body has been found which gives a strong killing effect without damaging the plant, suggests that finally some fluid fit for commercial purposes may ultimately be found.

Conclusions.

Working with the eggs of Aphis pomi it was found that :—

(1) Lime-sulphur at all strengths by itself was effective.

(2) Lime-sulphur with the addition of .2% calcium caseinate had a strong killing action at the strengths of 1 in 15, 1 in 20, and 1 in 30, whether applied in February or March.

(3) Other fluids releasing or containing finely divided sulphur or sulphur dioxide were comparatively ineffective.

(4) Combinations of caustic soda and nicotine had strong killing power if applied just before hatching but were useless at an earlier date.

(5) Certain of the coal tar products were very toxic, but most of them were inoperative and some damaging to the plant.

A NOTE ON THE EFFECT OF SULPHUR ON BLACK CURRANT MITE.*

By A. H. Lees.

In the Annual Report for 1919 reference is made to the effects of lime-sulphur spraying on control of Big Bud. This treatment has sometimes been promising and sometimes disappointing. It seemed necessary, therefore, to investigate more closely the action of sulphur on the migrating mites. Lime-sulphur itself is a compound body. It contains polysulphides which, when sprayed on to a plant, deposit a coat of sulphur, at the same time giving off sulphuretted hydrogen. The evolution of this gas lasts, however, for probably a short time only and any continued toxicity of the spray depends most likely on the action of the sulphur itself.

In order to be quite certain of the action of sulphur by itself, it was necessary to use it in the pure form and this was done by obtaining a sulphur cloud by means of an air current over the heated substance.† This cloud was projected into a closed glass bell jar and left for three days to allow the coarser particles to settle. The sides of the jar were thus covered with an invisible coating of sulphur.

A black currant twig, with some big buds on it, was placed with its lower end in water inside the jar. The jar was closed at the bottom by the bench of the laboratory, but had a small opening at the top. The experiment was done in spring, just when mite-migration was beginning, at a temperature that encouraged it,

The following details show the result of the experiment. 1st day—twig placed inside. 5th day—Heavy migration. Very few living and those just emerged. Some on stem of bud, but dead. Most at bud mouth opening. 7th day—ditto. 10th day—ditto, but few living. A few on stem of bud, but dead. 16th day—ditto. 24th day—All dried up and brown.

Under these conditions, therefore, there was a very decided killing effect, which lasted at least 16 days, even though air diffusion could take place to some extent through the slightly open top.

* Reprinted from the Journal of Pomology and Horticultural Science, Vol. III, No. 2.

† Barker and Wallace. A New Method of Sulphur Fumigation. Annual Report, Long Ashton Agricultural and Horticultural Research Station. 1921.

A similar experiment was done using a deposit of lime-sulphur on the inside of the bell jar. This deposit was well washed with water and dried before use to obviate any danger of the presence of sulphuretted hydrogen. 1st day—Twig placed in bell jar. 7th day —Mites emerging, but all killed. 11th day—Many mites emerged, a few living. None on stem. 13th day—ditto. Isolated mites on stem. 16th day—ditto, but more living. Fair numbers on stem, some living. Migration evidently proceeding, though slowly. 22nd day—ditto. 30th day—All dried up and brown.

The effect seemed to be the same as with pure sulphur, but it did not last quite so long.

A third big-budded twig was treated in a different way. It was held for a few seconds in the path of a sulphur cloud so as to be covered with minute sulphur particles. It was then placed in a moist closed bell jar. 1st day—Twig placed in bell jar. 7th day— Mites emerging, but killed. 11th day—Many mites. One or two (newly emerged) living, a few on stems dead. 13th day—ditto. 16th day—ditto, but rather more living, especially at opening of bud. Some living on stem of bud. 22nd day—Most dead and dried up.

This method, therefore, gave about the same control.

The following give the details for an untreated big-budded shoot kept in a closed bell jar. 1st day —Twig placed in bell jar. 5th day —Active, living. 7th day—ditto. All over the stem. 10th day— ditto. 16th day—ditto. 24th day—Still active, but only a few emerging.

There was, therefore, no interference with normal migration by keeping the mites in the close atmosphere of a bell jar. It was, indeed, necessary to keep them in a rather moist atmosphere as they are very liable to dessication in the laboratory.

Under indoor conditions, therefore, the migration went on for about three weeks, during which time all the sulphur treatments exercised general control. The influence of the lime-sulphur treatment seemed to be weak after the first fortnight, and the same applies to a lesser degree to the twig exposed to the sulphur cloud. Probably the supply of sulphur present was becoming exhausted.

These experiments clearly show the great value of sulphur in controlling mites and its effect seems to be very deadly. Its action, however, is limited by its comparatively short duration. In the field mite-migration may be proceeding for two and a half to three months, so a second or third application would appear to be necessary. If lime-sulphur is used, a second or third application must be at summer strength, since foliage has reached a fairly advanced stage, and consequently far less sulphur is deposited at the second or third spraying. A much greater difficulty is, however, the fact that at these two sprayings nearly all the sulphur is deposited on the

leaves instead of on the wood and big buds, which positions give the most effective control. In practice a second spraying at summer strength did not appear to increase the control, no doubt for the reasons discussed above.

The only solution to the problem would appear to be either dusting with a very fine sulphur powder or making use of a sulphur cloud. The former, if sufficiently fine powder could be obtained, might result in some burning and also might be troublesome on account of the deposit on the developing berries. The latter method would appear to be very promising, but there is at present no machine capable of giving the requisite cloud under open-air and commercial conditions. An attempt is being made to devise a suitable apparatus.

RED PLANT IN STRAWBERRIES AND ITS CORRELATION WITH "CAULIFLOWER DISEASE."*

By E. Ballard and G. S. Peren.

Introduction.

The trouble in the strawberry plant known by the various names of "Red Plant," Red Leg," "Red Leaf," and "Small Leaf" has been recognised by some growers for a number of years. It is, however, only of recent years and more especially in 1922 and the present year that not only have the symptoms of the disease become increasingly familiar, but the distribution enormously extended. To such a degree is this the case, that in certain districts the strawberry growing industry is seriously threatened. Definite evidence is forthcoming of the existence of this trouble in Cornwall, Devon, Somerset, Hampshire, Herefordshire, Kent, Sussex, Wisbech, and the Valley of the Cldye. The disease has not been reported from Herefordshire but the symptoms have been identified in that county by one of us.

Symptoms of Red Plant.

The typical "Red Plant" as seen in early Spring may be briefly described as follows—(These refer to symptoms shown by the variety, Royal Sovereign).

General Appearance.—The more prominent symptoms are most easily recognised when growth begins in the Spring. The most marked feature of afflicted plants is the deep blood red colouration of the young petioles and the under sides of the unfolding leaflets. In the case of the latter the colouration may be more accurately described as "plum."

In comparison with normal plants, "Red Plants" tend to be undersized, this being most marked in the case of long-standing infections. In addition blindness or partial blindness is usually present.

Detailed examination reveals the following:—

Leaves and Leaf Stalks.

(*a*) *The Petiole.*—Two main types are shown. Firstly, one which tends to be swollen at the base and tapering to the apex.

* Reprinted from the Journal of Pomology and Horticultural Science Vol. III, No. 3.

This petiole is invariably long in proportion to the size of the leaflets which it carries and generally of a deep red colour.

The second type might best be described as a petiole and leaf in miniature. Both are usually heavily suffused with red. In extreme cases these structures may be most minute.

A diagnostic character of both these types is the marked reduction in hispidity amounting frequently to a sparse pubescence.

(*b*) *The Leaflets* which are borne on petioles described under (*a*) show considerable variation. In advanced cases of infection they may be represented by mere remnants of only one or two of the midribs, and from this show all grades up to small but perfectly formed reddened leaflets. The reduction in size or complete absence of one leaflet is a frequent symptom, this condition in the latter case being accompanied by deformities in the two leaflets present. Before complete expansion these leaves may be compared in appearance with the developing fronds of bracken when but a few inches high. We feel this simile to be so apt that we have adopted the term frond to describe this condition of growth and propose to use it for such in this and subsequent papers on this subject. Working further up the scale towards normality leaflets are found in which the stunting effect is far less marked, and the deformities are reduced to curled and cup-shaped leaves, the latter being apparently due to some inhibition of marginal growth.

(*c*) *The Stipules.*—These are frequently large in proportion to length of the petiole and of a very deep red colour, but it must not be taken that this character is constant.

(*d*) *The Crown.*—The crown is usually attenuated, more especially in the case of blind or partially blind plants. In cases where the plant has apparently contracted the disease at a very early age the formation of lateral crowns may be entirely inhibited although such severe examples are rarely found. In other cases lateral crowns are produced, but these crowns are extremely small and thin and give rise to the miniature leaves referred to above (*b*). Where the infection is slight the size of the lateral crowns may be normal in comparison with the original crown, but all may be said to be undersized and attenuated.

Cauliflower Disease.

True " Cauliflower Disease " is a condition caused by *Aphelenchus fragariæ*. Ritz. Bos. The lateral crown becomes much swollen and the flowers stunted and distorted into a cauliflower-like bunch from which the disease derives its name. The blossoms when they appear show a variety of deformity. The calyx may be enormously developed and the receptacle undersized and irregularly formed. In cases of medium infection the inflorescence, instead of remaining bunched as in the true cauliflower condition, is able partially to develop, but the scape and the pedicels are much thickened and stunted and the flowers of the cyme show considerable malformation. Frequently the scape is much fasciated.

To go into the details of foliar malformation—extreme cases are those in which the petiole is represented by nothing more than a short swollen protuberance sharply tapering to a fine point which is frequently dead. Working upwards from this as the lowest expression we pass, by way of the typical fronds through the leaf with the swollen petiole and either two leaflets and a rudiment or else two leaflets and the third deformed and twisted in various ways. The next stage is a leaf consisting of three leaflets which exhibit a very characteristic crumpling or curling. In all cases where leaflets are produced by the above types they are characterised by a tough leatherly texture. In this disease as normally recognised there is no marked redness, the typical colouration being a blue-green tint about the leaves.

The miniature leaves of " Red Plant " are also often produced. These have been already described above.

Correlation of the two Diseases.

After examination of a very large amount of material a constant overlapping of symptoms of " Red Plant " and " Cauliflower " disease has been definitely established.

To begin with, the typical colouration, giving the " Red Plant " its name, may greatly diminish after a few weeks. Stripped of this character the plants assume an appearance identical with mild cases of " Cauliflower Disease " if the flower trusses of the latter are removed, the bases of their petioles more particularly assuming the watery green colour typical of the thickened parts of "cauliflower" plants. This loss of colour has been carefull followed in marked plants in the observation plot at this Station. This plot consists of 5,000 plants a very high proportion of which are red.

Having fully acquainted ourselves with the characters of bad cases of " Cauliflower Disease " we proceeded to work down the scale of degrees of infection noting the slightly changing symptoms. As we established the latter we found ourselves, towards the end of

the scale, examining plants which normally we should have put down as "Red Plants," the symptoms merging with the finest gradation into those of the latter disease. In some cases we have found blossom trusses on red coloured "Red Plants" which we were able without hesitation to say showed symptoms of "Cauliflower Disease."

The connecting characters are as follows :—

(1) The production of the "fronds" described above in their various stages of development.

(2) Reduction in the number of leaflets.

(3) Deformity of surviving leaflets.

One type of deformity is that of a leaflet very greatly reduced in size. The marginal growth is inhibited and such leaflets have the appearance of suffering from caterpillar attack, looking as though large "bays" have been eaten out of the margin. These leaves show an inhibition so general that very little central growth takes place, which in larger stronger leaves, although the marginal growth is inhibited, the central growth proceeds more or less normally with the result that a bellying of the leaf takes place.

(4) Deformation of the leaf margin including an oak leaf type.

(5) Coarsening and thickening of the leaflet, such leaflets having a dark green colouration.

(6) Crumpling of the leaflets and the cup-shaped formation described above.

"Small Leaf."

Thicket.

There is yet another trouble of strawberry plants which some growers recognise as "Small Leaf."

This condition may be described as follows :—

The early stage is characterized by fine undersized growth accompanied by a certain amount of reddening, which later diminishes. Shortly, excessive crown formation begins and is continued until a dense mat of leafage is produced. The petioles, leaflets and crowns are perfect in form but undersized, the majority of the latter being blind. Tho whole plant, in fact, appears a dense mass of undersized and attenuated growth, accompanied by partial or complete blindness.

At the bases of the crowns are found, as the result of careful examinations, numerous fronds and small deformed leaves comparable with those found in "Red Plant" or "Cauliflower" disease, and from this fact and the finding of *A. fragariæ*, we are led to

conclude that *A. fragariæ* is in this case also the pathoganic organism.

Conclusions.

A consideration of all the above factors lead one to conclude that " Red Plant " and " Cauliflower " are one and the same disease and are simply either the different types of reaction on the past of the plant to the same noxious stimulus, or different degrees of infection, or again the result of infection contracted at different stages of growth. An examination of the large quantities of material which we have had at our disposal from several different districts would by itself almost suffice to convince one that the two diseases were the same, but still further and more convincing evidence is forthcoming, and this is given by the fact that *Aphelenchus fragariæ*, Ritz. Bos. can usually be found in the growing points of " Red Plants," and often in the growing point of runners on " Red Plants." Their position and method of feeding are identical with those in undoubted " Cauliflower " diseased plants, that is, they are to be found between the developing leaf rudiments on each side of the growing point.

With regard to the spread of the disease, we are led to conclude that the stolon can be infected from the parent plant and hence the young plant produced on the stolon. It is not improbable that infection can take place by boots, horses and implements, yet at the same time careful roguing of parent plants cannot fail to assure a considerable reduction.

The question of immunity of certain strains arises. All that can be said at present is that none of the 50 varieties examined to date have shown complete immunity.

It is curious to note that in certain strawberry areas where a small plant for the production of fruit is favoured " Cauliflower " is not produced in its most marked form and not until we found in the course of our investigations examples of this trouble in strongly growing plants were we able to connect the two conditions.

The term " Red Plant," " Red Leaf " or " Red Leg " is an unfortunate one as, firstly, redness does not persist even in Royal Sovereigns and, secondly, although other varieties get the disease they do not go red.

Much work of a corroborative nature remains to be done, and the methods of infection, the life history of the eelworms and possible methods of control are all problems yet to be solved. These matters are now under investigation.

THE PURPLE LEAF BLOTCH OF STRAWBERRY.

By H. R. Briton-Jones.

This disease, the cause of which was previously unknown, was very prevalent in the western counties this summer. It caused a considerable amount of damage to the plant since the blotches in a good many cases involved over fifty per cent of the total leaf surface. The variety which seemed to be most badly affected was Royal Sovereign, but other varieties were also attacked.

The disease was at first studied as being a possible bacterial or fungus disease. Cultures carefully made from the smallest spots, however, did not yield any organism which might be reasonably suspected as causing the disease. Subsequent observations in the field, however, showed beyond doubt that the trouble is due to attack by Aphis (*Myzus fragariella*, Theobald), when the leaves are still young and before they become unfolded. Examination of young leaves show the presence of Aphids between the folds. When these young leaves are unfolded by hand and held to the light the portions of the leaves which the Aphids have been sucking can be distinguished as pale green areas. As the leaves grow and become unfolded, these pale green areas turn a reddish-purple colour. There are cases where the very young leaves have been punctured in so many places that they never manage completely to unfold and expand normally. This is due to the fact that the punctured tissues are so badly damaged that they become dried up and are unable to grow. The unpunctured areas continue normally to increase in size with the result that they exert a pull on all sides of the damaged areas. Thus the affected leaves always have a crinkled appearance and the damaged areas often split. On a mature leaf the reddish-purple blotches measure from 1 mm. to 1 cm. in diameter. Leaves which have not been attacked by Aphids before they completely unfold do not become discoloured in the above manner if subsequently attacked by large numbers of Aphids. So far control measures have not been worked out, but field observations indicate that spraying will not meet the case owing to the difficulty of wetting between the close folds of the very young leaves.

Photo by] [*A. D. Turner*

A Typical "Red Plant."

Photo by] [*W. Camps*

Foliage from "Red Plant," showing Largest and Smallest Leaves.

Photo by] [*W. Camps*

FOLIAGE FROM A NORMAL PLANT, SHOWING LARGEST AND SMALLEST LEAVES.

Photo by] [*W. Camps*

A TYPICAL "CAULIFLOWER" PLANT.

Photo by] [*W. Camps*

ADVANCED STAGES OF "CAULIFLOWER" DISEASE.

Photo by] [*W. Camps*

TYPES OF FOLIAGE FOUND ON BOTH "RED PLANTS" AND "CAULIFLOWER" PLANTS.

Photo by] [*A. D. Turner*

Flower Trusses from "Red Plants," showing Normal and Typical Cauliflower Symptoms.

(1) Normal Truss. (2, 5) No Stamens, Abortive Flowers. (3) No Styles.
(4) Truss from "Red Plant."

PEAR LEAF BLISTER (Taphrina bullata, Tul).

By H. R. Briton-Jones.

This infrequent disease was quite common on different varieties of Pears in many localities this summer. The fungus produces convex and concave blisters on the leaves. At first the blisters are green in colour. Later, however, they turn black on the upper surfaces of the leaves, whilst the lower surfaces become covered with a whitish covering which consists of the fruit bodies (asci) of the fungus. At an older stage the asci have a brownish appearance. Generally speaking, the disease in itself is of little importance, although the presence of a large number of blisters must interfere to some extent with the functions of the leaves. On the other hand, the importance of the disease is increased somewhat if the variety of Pear attacked is also subject to the far more serious disease Scab (*Venturia pirina*. Aderh.). The tissues of the leaves which have been attacked by the blister fungus later become infected by the scab fungus which produces hundreds of spores on the blisters, particularly on the under surfaces (See Fig. viii). The scab fungus can infect healthy tissues of the leaves, but the number of such infections were far less than those which occurred on the tissues which had been previously attacked by the Blister fungus. This is probably due to the fact that the scab spores become lodged more easily and securely on the somewhat woolly surface produced by the asci of Taphrina bullata, than on the smoother surface of the healthy leaf. It is also interesting to note that scab infections did not occur to anything like the same extent on the portions of the leaves affected by the Leaf Blister Mite (*Eriophyes pyri*). Thus by facilitating infection of the leaf by the scab fungus the Leaf Blister disease indirectly increases the source of infection of the Pear twigs and fruit by the more destructive scab fungus. The Pear Leaf Blister disease can probably, like similar diseases, be controlled by spraying with "summer strength" Lime Sulphur as used against scab, namely 1 gallon of the concentrated solution added to 29 gallons of water.

The degrees of attack on different varieties of Pears by the Pear Leaf Blister were noted this year at Long Ashton. The results

are as follows :—

Name of Variety.	*Degree of Attack.*
Durondeau	Slight
Beurre d'Amanlis ..	Bad
Pitmaston Duchess ..	Slight
Triomphe de Vienne ..	Clean
Beurre Hardy	Medium
Doyenne de Comice ..	Slight
Winkfield	Slight
Emile d'Heyst	Clean
Conference	Slight
Petite Marguerite ..	Clean
Bellissime d'hiver ..	Slight
Dr. Jules Guyot ..	Medium

PECTIN AND ITS HYPOTHETICAL PRECURSOR "PROTOPECTIN."*

By F. Tutin.

It has long been known that the expressed juice of unripe fruits contains very little pectin, and that when the crushed marc is subsequently extracted with cold water, only small, additional quantities of this substance are obtained. In contrast to this, when a soft, fully ripe fruit is pressed, the juice contains a considerable amount of pectin, and further, and larger quantities may readily be obtained by extraction of the marc with cold water.

When, however, an unripe fruit is heated with dilute hydrochloric acid it becomes thoroughly disintegrated, and the liquid obtained by straining and pressing the resulting mixture is rich in pectin. This has led to the assumption that unripe fruits contain an insoluble compound which might be regarded as the parent substance of pectin, and which, by hydrolysis, during the process of ripening, or when heated with acid, becomes converted into ordinary, soluble pectin. To this insoluble compound the name "protopectin" was given by Fellenberg (1918),† and it corresponds to the "pectose" of earlier investigators. It has, moreover, been assumed that the presence of this "protopectin" was a cause of the hardness of unripe fruits, and that its gradual change into soluble pectin was a feature of the process of ripening.

After having worked for some time with pectin, however, it occurred to the present author that the generally accepted explanation of the apparent defficiency of soluble pectin in unripe fruits might not be the correct one. To quote one observation: if it be attempted to filter a solution containing only a relatively small concentration (0.5 per cent. or even less) of pectin through a reasonably efficient paper it will be found that, after a very few moments, filteration becomes extremely slow. The filtrate then collected contains only a very small proportion of pectin, the greater part of the latter substance being retained on the surface of the filter as a gel-like layer. Considerable quantities of distilled water may then, in course of time, be passed through this filter, when the

* Reprinted from the Biochemical Journal, 1923, XVII, 510.

† Fellenberg (1918) Biochem. Zeitschr. 85, 118.

pectin continues to be removed, but at an extremely slow and apparently constant rate. Now it seemed that conditions analagous to this might prevail in the case of hard, unripe fruit, where really efficient disintegration of the tissue is peculiarly difficult to attain, particularly when it is considered that fruits contain products which, though soluble in alcohol, are insoluble in water, and would certainly hinder the access of the latter to the pectin occulded in the tissue.

In view of these considerations and also taking into account the fact that no direct evidence of the existence of " protopectin " has ever been obtained, the following alternative explanation of the fact that fruits not fully ripe retain part of their pectin content in an apparently insoluble form, presented itself to the author : namely, that no such substance as " protopectin " exists, but, that the persistent retention of pectin in an apparently insoluble form by the tissue of incompletely ripe fruits is due partly to the presence of substances insoluble in water but soluble in alcohol, but more particularly to the great difficulty in attaining, by mechanical means, really efficient disintegration of the unripe tissue. In other words, it is suggested that the presence of " protopectin " is not a cause of the hardness of the tissue of unripe fruits, but that the behaviour of this tissue, described above, is the effect of its dense nature.

More than two years ago a few preliminary observations were made which tended to support this view. The material employed was a very finely ground sample of dried pomace (the presscake from the cider press). Three quantities, each weighing 30 grams, were exhaustively extracted in a Soxhlet apparatus ; No. 1, with water only ; No. 2, first with alcohol, and subsequently with water ; whilst No. 3, after extraction with alcohol, was heated in an autoclave at 110° with dilute hydrochloric acid for one hour, and subsequently exhausted with boiling water. The amounts of pectin obtained from the three extracts were, respectively, 1.4 gms. ; 1.6 gms. ; 1.6 gms. Had " protopectin " been present the last extract should have yielded the largest amount of pectin, whilst the inhibiting effect of the presence of alcohol-soluble substances is shown by the lesser amount of pectin obtained from the first extract.

It was, therefore, decided to conduct some experiments with unripe apple tissue, taking precautions to remove all the substances soluble in alcohol and also to ensure as complete a mechanical disintegration as was possible with the means available.

The variety of apple selected for this purpose was Bramley's Seedling. The fruit for the experiment described below was picked on August 29th, 1922, when it was far from being in a ripe condition, These apples, when pressed, yielded a juice which contained only a very small amount of pectin. A quantity of the fruit was peeled, deprived of all core tissue, thinly sliced, and then placed in alcohol,

these operations being conducted as quickly as possible. The weight of fresh, sliced material taken was 286 grams. The alcohol into which the sliced fruit had been placed was decanted, and replaced by fresh solvent, and this treatment was continued, at the ordinary temperature, so long as anything was dissolved from the apple tissue. The latter was then well crushed in a mortar, brought on to a filter, and well washed, first with absolute alcohol, and finally with ethyl acetate. After drying, first in the air, but subsequently in a vacuum over sulphuric acid, the material weighed only 8.9 grams. This dry material was then submitted to a very thorough grinding in a mortar and the whole of it passed through a sieve the meshes of which were approximately 1-200th of an inch square. The ground product then weighed 8.8 grams. This finely ground tissue was then well stirred at frequent intervals, for about two hours with 1300 cc. of cold distilled water* and subsequently allowed to settle for about 22 hours. The supernatant liquid decanted, and the process repeated. In all, 25 extractions were made. The pectin content of each of the last ten extracts was very small, and apparently constant. The residual, wet marc was then mixed with about a litre of alcohol, collected on a Buchner filter, well washed, first with alcohol and subsequently with ethyl acetate, presesd, andallowed to dry. The dry material was re-ground with fine, sifted sand † in a very thorough manner, so that the sand became crushed to micoscopic, sharp edged, flint-like fragments. After again passing the product through the above-mentioned sieve the extractions with water were repeated as before. In this case it was found that only 10 extractions were necessary to reach the point where only a very small amount of pectin was removed. The marc was then washed with alcohol and ethyl acetate and dried as previously described, after which it was again very thoroughly ground with the finely comminuated sand which had passed through the sieve after the first re-grinding. On repeating the treatment with water, as before, only seven extractions were found necessary. At this stage the material was carefully examined under a microscope, samples being taken two minutes after it has been vigorously stirred with distilled water, some from near the surface of the mixture and others from the lowest portion. The former showed only fragments of cell walls together with minute particles of silica, whilst the latter contained, in addition to salica, some small fragments of vascular tissue which has escaped complete disintegration, together with one or two groups of about three partically broken cells still adhering together. It was evident that disintergation had been

* In order to ensure that the dry powder would readily mix with the water it was found convenient in the first instance to moisten it with a little alcohol.

† Purified by extraction with acids followed by strong ignition.

very thorough, although not absolutely complete, and it was concluded that a small amount of soluble pectin would still be retained in the tissue. Nevertheless, it was not deemed necessary to continue the laborious process of grinding and extracting in order to obtain proof of the absence of "protopectin." The residual marc was therefore heated in an autoclave at 110° with $N/_{20}$ HCl under the conditions described by Carré (1922)† and subsequently extracted with distilled water four times in the manner described. The fourth extract contained an amount of pectin that was scarcely detectable. The pectin present in all the four series of extracts obtained, as above described, was, in each case, directly estimated as such. After concentration under diminished pressure, each extract was treated with a large volume of alcohol, the pectin collected, dried in a vaccum and weighed. The method proposed by Carré and Haynes (1921)‡ was not adopted as their procedure represents as pectin any acid which might happen to be present and which yields a calcium salt insoluble in dilute acetic acid. The following is a summary of the results obtained by the present author :

Weight of fresh apple tissue. 286 grams.	Weight of ground and dried tissue after treatment with alcohol. 8.80 grams.	Volume occupied by dry ground material. About 28 cc.
	Weight of pectin from 8.80 grams of dry tissue.	Volume occupied by wet tissue on subsidence from water. (Approximate).
	grams.	cc.
1.—After fine grinding	*1·9347	330
2.—After re-grinding, with sand ..	*1·5104	220
3.—Again re-ground with sand ..	0·3238	110
4.—Autoclaved with X Cl.	0·1005	115

The volumes occupied by the marc are given as supplying additional evidence of the change produced by the various treatments.

It is seen from the above results that, after the removal of the "soluble pectin" from the original, finely ground tissue, a further

† Carré (1922). Biochem. J. 16, 704.

‡ Carré and Haynes (1921). Biochem. J. 15, 60.

* These two weights, particularly the first one, are very slightly greater than the actual weight of pectin obtained. This is because, during the decantation of the pectin solutions from the marc, a very small amount of the latter was unavoidably removed with the pectin solution, and it was not subsequently separated owing to the above-mentioned difficulty of filtering through a good paper solutions of pectin, which are not very dilute. The liquids decanted after the third and fourth treatments, however, were each exactly filtered, so that the weights of pectin yielded by them are strictly comparable. Nevertheless, the total percentage of pectin calculated on the weight of fresh tissue taken, appears to be high in comparison with results previously obtained. This is attributed, in part, to the efficiency of the grinding and extraction, but also, probably, to the unripe condition of the fruit, since fully ripe fruit from the same trees was found to contain at least 50 per cent. more water.

and almost as great amount may readily be dissolved by treatment with cold, distilled water when the material had merely been submitted to a process of more efficient mechanical disintegration. The amount of pectin subsequently obtained after treatment with acid is insignificant, and its retention by the marc is obviously due to the fact that quite complete disintegration of the tissue had not been attained, even after the drastic grindings that had been resorted to.

The only conclusion that can be arrived at is, therefore, that "protopectin" does not exist, but that all the pectin present in the apple occurs in the ordinary, soluble form. The problem of estimating pectin in fruits, therefore, appears to resolve itself, in the first instance, into one of attaining complete disintegration of the tissue. It seems likely that this would most readily be accomplished by resorting to the treatment with dilute HCl employed by Carré (*loc. cit.*) for the hydrolysis of the supposed protopectin.

After the commencement of this work a paper, referred to above, was published by Carré, dealing with the changes which occur in the "pectic" constituents of stored fruit. The conclusions arrived at during the present investigation offer a ready explanation of some of the results there described. In the first place it is probable that the "considerable variations" in the pectin content of stored fruit observed by Carré were due, not so much to a large sampling error, as suggested by her, but to differences in the degree of mechanical disintegration of the various samples of tissue before extraction of the soluble "pectin" The great deficiency of pectin found by her in the early stages of ripening would appear to be chiefly due to lack of efficient disintegration, which is especially difficult to attain when the fruit is in an unripe condition. No special precautions seem to have been taken by Carré to ensure thorough grinding, and, in fact, she appears to recognise that this had not been attained. Thus on page 708, when describing the estimation by treatment in an autoclave at 110° with dilute HCl of protopectin in tissue which was supposed to have been already deprived of soluble pectin, she states :—"The material became thoroughly disintegrated during the process" . . . . Then again, she states that "A series of estimations of pectin and protopectins carried out at regular intervals on the same apples showed that a very definite relationship exists between them and that the changes in the two constituents tend to be equal and opposite in amount." This, also, is obviously another result of varying degrees of inefficient mechanical disintegration. Naturally, the more pectin that can be removed after the first process of partial disintegration, the less there is left to be removed when the product has been submitted to a process which ensures complete disintegration.

It was observed by Carré that after crushing, and thoroughly washing apple tissue with water, a small amount of pectin continues to be removed during several weeks, on further treatment with water. This behaviour is attributed by the present author to the slow rate of diffusion of pectin from insufficiently disintegrated tissue.

A NOTE ON THE HYDROLYSIS OF PECTIN.*

By Frank Tutin.

In a previous communication† the present author showed that when pectin was treated with cold, aqueous alkalis or with the enzyme, pectase, pectic acid was formed, together with methyl alcohol and acetone. It was stated, moreover, that "the proportion of acetone to methyl alcohol produced appeared to be about one part of the former to two of the latter," and, furthermore, that "it appears likely, therefore, that pectin is the dimethyl-*iso*-propenyl ester of pectic acid." This conclusion was not based on any indirect method of estimation of either the methyl alcohol or the acetone, which cannot easily be determined accurately in the presence of one another, but it was a considered conclusion based on the actual amounts of these substances obtained after their separation by a prolonged and careful fractional distillation and subsequent treatment of the "acetone fraction" with calcium chloride. The amount of material dealt with was large, and more than 3 gms. of practically pure acetone were obtained. The author sees no reason to modify his original, somewhat guarded statement.

In view, however, of several personal communications from an authoritative American source the subject appears to require a little further explanation.

The author's statement regarding the formation of acetone on cold* dydrolysis was at first denied, but has been subsequently confirmed, here and in America, but it must be pointed out that too prolonged treatment of the pectin with water at a high temperature, especially in the presence of acid, results in a loss of both methyl alcohol and acetone. It has now been stated, however, that whether the percentage of methyl alcohol yielded by pectin is calculated from the amount of alkali required to hydrolyse the latter, or estimated by Zeisel's method, practically identical results are obtained. From this it is concluded that there is hardly room for an *iso*-propenyl group in the molecule. It will at once be seen, however, that the amount of alkali required to eliminate an *iso*-propenyl group is the same as that required for a methyl group. Moreover, when employing Zeisel's method, acetone (or an *iso*-propenyl group) is converted into *iso*-propyl iodide, which readily volatilises and yields the same amount of silver iodide as would a methyl group.

This behaviour of acetone does not seem to be generally realised, and it is considered advisable to draw attention to it as several previous workers have employed Zeisel's method for estimating the methyl alcohol yield by pectin.

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* Reprinted from the Biochemical Journal, 1923, XVII,83.

† Tutin (1921). Biochem. J. 15, 494.

ACIDITY AND TASTE IN APPLE JUICES.

By Otto Grove and F. Summers.

An electrometric method has been used for investigating the acidity of freshly expressed apple juices and also the changes in acidity which occur in fermenting apple juices.

This method is dependent upon the concentration of hydrogen ions in the juice, and the measurement of this concentration gives a clearer picture of the physiological acidity and possibly the acidity of taste than the usual titration methods.

The relation between the acidity as determined by titration and that determined by measuring the concentration of hydrogen ions has been obtained for thirty-three fresh juices. This relation is in no way regular and further study has shown that other constituents of the juices, *e.g.*, pectin and sugars, affect the physiological acidity by depressing the hydrogen ion concentration Such changes are not shown by a titration with indicators.

The acidity changes in four selected juices, viz., Cap of Liberty, Wootton's Carrion Red, Kingston Black and Cummy Norman, have been investigated periodically during the year by titration and by the electrometric method. Again, there has been found to be no clear relation between the two acidities in the unfiltered juices, but the measurements of hydrogen ion concentration gave a different picture of the acidity changes from the figures obtained by titration.

In filtered samples there was closer agreement between the two acidity values at every stage. It is possible that some of the filtrable constituents, by depressing the hydrogen ion concentration, regulate this between limits which are most suitable for the fermentration process.

A regulatory action of this kind has been shown for pectin and the sugar levulose, when added to solutions of malic acid.

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* Acetone is yielded by a great variety of products on treatment with hot alkali.

THE INFLUENCE OF PRESSURE DURING THE LATER STAGES OF THE PRIMARY FERMENTATION OF CIDER.

By Otto Grove.

An investigation was begun during the 1922-23 cider-making season to determine the effect of pressure during the later stages of the primary fermentation of apple juice, particularly in relation to flavour, natural clearing and rate of fermentation.

In January, 1923, nine different unfiltered ciders in different stages of fermentation were placed in soda-water syphons and kept at room temperature. As controls further samples of the same cider in glass-bottles of approximately the same size and shape as the syphons, closed with an ordinary fermentation trap to prevent access of air without increase of pressure, were kept alongside.

The syphons and bottles were held under close and regular observation. It was noted that after one month the liquid in the syphons in nearly all cases was clearer than in the controls. This difference was not so marked after two months, when in about half of the corresponding samples the ciders were equally clear in both cases, the controls by that time being mostly well advanced in natural clearing.

The syphons were opened in July, 1923. The pressure in the syphons when opened was not determined, but it was obvious when disgorging the cider from the syphons that very considerable pressure had been developed in all cases.

The table overleaf summarises the results for the three characters above mentioned,

As will be seen from the following, the differences in the final specific gravity between the samples fermented under pressure and the controls were generally material and in some instances quite remarkable, in the case of Kingston Black being as much as 19 points, which corresponds very nearly to 5 per cent. of sugar. In only three cases—very rapidly fermenting juices from mixed fruit —were the differences less than 8 points. It may therefore be concluded that fermentation under pressure during the later stages of primary fermentation proceeds more slowly than under ordinary atmospheric pressure. The point is one of important possibilities

Kind of Cider.	*Specific Gravity.*		*Clearing.*	*Flavour.*
	Jan. 1923	*July.* 1923		
Cummy Norman—				
(*a*) Under pressure	1·029	1·016	Same as control.	Better than control.
(*b*) Control ..	1·029	1·003		
Eggleton Styre—				
(*a*) Under pressure	1·030	1·019	Ditto.	Ditto.
(*b*) Control ..	1·030	1·010		
Mixed Apples, S.E.1.—				
(*a*) Under pressure	1.010	1.003	Ditto.	Ditto.
(*b*) Control ..	1·010	1·000		
Mixed Apples, H—				
(*a*) Under pressure	1·023	1·010	Ditto.	Ditto.
(*b*) Control ..	1·023	1·002		
Kingston Black, M—				
(*a*) Under pressure	1·041	1·020	Better than control.	Much better than control.
(*b*) Control ..	1·041	1·001		
Mixed Apples, Cr. 1.—				
(*a*) Under pressure	1·023	1·009	Ditto.	Better than control.
(*b*) Control ..	1·023	1·000		
Mixed Apples, S.E.2.—				
(*a*) Under pressure	1·020	1·003	Same as control.	Ditto.
(*b*) Control ..	1·020	1·003		
Mixed Apples, Cr. 2.—				
(*a*) Under pressure	1·022	1·008	Better than control.	Ditto.
(*b*) Control ..	1·022	1·000		
Mixed Apples, S.E.3—.				
(*a*) Under pressure	1·017	1·002	Ditto.	Same as control.
(*b*) Control ..	1·017	1·000		

for the production of natural sweet ciders under commercial conditions. The evidence at present available does not justify an attempt to explain this pressure effect, but further investigation may furnish the reason.

Another fact established by these experiments is that cider fermented under pressure is better in flavour than the corresponding control. This improvement was very marked in some cases. The fruity aroma was also much more pronounced and in many cases the difference in this respect in comparison with the control was very striking.

The fruity aroma of a cider is to a large extent dependent upon volatile esters, partly from the apples and partly developed during the fermentation ; as these bodies are very volatile, they are partly lost during ordinary fermentation.

An attempt was made to collect these volatile aromatic bodies developed during the fermentation of cider by connecting two casks containing the fermenting juice of Kingston Black apples, which produce a specially aromatic cider, with bottles placed in such a way that all the gas evolved during fermentation had to pass through the bottles. The collecting bottles were kept at a temperature of—10° C., one of them empty, the other half filled with a mixture of equal parts of alcohol and water. After two months the collecting bottles were examined and it was found that the liquid in the bottle containing the alcohol mixture had a faint fruity odour, which, however, soon disappeared at ordinary temperature. In the empty bottle no volatile substances were collected. Probably a much lower temperature than was available is needed to collect these very elusive aromatic esters.

As regards the extent of clearing of the ciders the final result as between those under pressure and those not under pressure did not as a rule present much difference. There was, however, as already indicated, a definite difference in the rate of clearing, the pressure-treated ciders clearing earlier. Since, as has been shown, there was a material difference in the extent to which fermentation proceeded in the two series, the controls fermenting to a greater degree of attenuation, it is likely that their slower rate of clearing was associated with this behaviour, the yeast remaining active over a longer period and therefore not being deposited so rapidly.

It remains to be seen from further investigation whether practical use can be made of the advantages of fermentation under pressure which this research, so far as the first season's trials go, appears to have definitely established.

CIDER STORAGE EXPERIMENTS, 1923.

By Otto Grove.

The difficulty of prevention of deterioration in cider under ordinary conditions of storage in wood after the cessation of active fermentation is recognised by all cider makers. The deterioration referred to is mainly due to acetification, which is the result of the action of acetic bacteria on the weakly-alcoholic beverage in the presence of oxygen. So long as entry of air into the storage vessel is prevented by the maintenance of an adequate pressure of carbon dioxide in the liquor, the latter can be kept in sound condition: but when, as the cider ages during the spring and early summer following the making season, the generation of that gas becomes less and less and finally practically ceases, unless the storage vessel is gas-tight the internal carbon dioxide pressure gradually approaches vanishing point and access of air to the liquor follows with the inevitable acetification. The extent of the latter is variable, being dependent upon well-known factors, but the degree of gas-tightness of the storage vessel is the first consideration.

In practice these vessels are in the great majority of cases wooden casks, the degree of porosity of which and the closeness of fitting of the individual staves vary materially. The size and shape of the cask determine the proportion of surface of wood to volume of liquor and are therefore important in this connection. Hence the larger cider makers with their great storage casks holding several thousand gallons of liquor are less affected on that account than the smaller maker who stores in pipes or hogsheads: but to all the introduction of a gas-tight storage vessel of reasonable cost, whether of wood or other material, would be a boon. Hitherto all gas-proof vessels, such as glass-lined cement tanks and glass-enamelled steel tanks, have been almost prohibitive in cost. On that account experiments on storage vessels have recently been started at Long Ashton. It is unlikely that a satisfactory solution to a problem of this kind will be quickly arrived at: nevertheless some of the observations made and the data collected in the various experiments appear worth putting on record, both as a presentation of facts bearing on the problem and a possible help to other workers. The following account of the 1923 trials is therefore contributed as a progress report on the subject.

In the first instance an attempt was made to prevent evaporation and render gas-tight casks of the hogshead size by the application of various covering materials to the wood, the object being to block the pores of the latter and to fill any gaps between the staves.

Seven casks were selected as nearly as possible alike. The casks were freshly emptied wine casks made of chestnut, each with a capacity of 50 gallons. One cask was kept as a control. Two were treated with paraffin wax, the paraffin wax being sprayed hot into the dry cask, so that the whole inside surface was covered with a thin, even layer. Two casks were treated with a proprietary varnish, A, and two were varnished on their outside with ordinary oak-varnish.

All the casks were filled with the same cider and closed by means of long tapering wooden bungs covered with several layers of calico treated with hot paraffin wax and driven tightly into the bunghole. The lower ends of these bungs dipped into the cider, shrinkage by dessication thus being prevented. The casks were kept in a part of the cider house where they were exposed to a considerable amount of draught.

The filtered cider used for the experiment had the following composition when placed in the casks on March 3rd, 1923 : specific gravity, 1.013 ; total acid (as malic) .57% ; volatile acid (as acetic) .036% ; tannin .18% ; alcohol 3.2%.

After three months a small sample was taken out of some of the casks for analysis, the quantity removed being replaced with the same amount of the same cider, kept in reserve for this purpose in a sealed container. The analyses were as follows :

	Specific Gravity.	Total Acid %	Volatile Acid. %
Control Cask	1.009	.58	.056
Waxed Cask, No. 1	1.008	.56	.060
"Varnish A" Cask, No. 1	1.010	.62	.086
Varnished Cask, No. 1	1.008	.60	.073

It will be seen that the specific gravity had fallen 3—5 points, that the total acid had increased in the case of the last two samples and that there was a marked increase in the amounts of volatile acids in all cases.

All the casks were finally examined after six months with the following results :

	Loss by Evaporation. c.c.	Specific Gravity.	Total Acid.	Volatile Acid. %	Growth on surface of liquid.
Control Cask ..	8020	1.005	.46	.104	A little mycoderma.
Waxed Cask, No. 1	8330	1.002	.44	.139	Some mycoderma.
Waxed Cask, No. 2	8970	1.002	.40	.090	A little mycoderma.
"Varnish A" Cask. No. 1	8320	1.005	.55	.099	Some mycoderma.
"Varnish A" Cask, No. 2	6180	1.005	.52	.094	Some mycoderma.
Varnished Cask, No. 1	7120	1.003	.46	.097	Hardly any mycoderma.
Varnished Cask, No. 2	6170	1.002	.46	.084	A little mycoderma.
Control in bottle (bottled 3rd March, 1923)	Nil	1.007	.47	.054	

The first column in the preceding table shows that the loss due to evaporation varied between 8970 c.c. corresponding to 4% and 6180 c.c. corresponding to 2.7%. The smallest loss took place in the " Varnish A " cask No. 2 and in the varnished cask No. 2 ; in both cases the loss was about three-fourths of the loss in the control.

As regards the specific gravity, it was lowest in the waxed and in the varnished casks. The total acid was highest in the " Varnish A " casks. The figures for the volatile acids give an indication of the acetification that had taken place during storage. The difference between the control and the treated casks was not very conspicuous. The high figure for waxed cask No. 1 was probably due to a small crack at the top of the cask.

There are some features of interest in these results which are in some respects outside the scope of the present subject : their consideration must be deferred for a more appropriate occasion.

Comparing the flavour of the samples, all tasted somewhat acetic ; in other respects the difference in flavour was not very marked. The samples from the varnished casks seemed somewhat inferior to the control. The samples from the " Varnish A " casks had a slight aftertaste due to the preparation.

From these results it did not appear that the different treatments of the casks had produced any appreciable advantage compared with the untreated cask.

In France most of the modern cider-factories, even quite small ones, store their cider in closed tanks made of concrete lined with glass plates. In such containers the cider keeps very well indeed. No evaporation takes place, and the liquid is completely excluded from the influence of the air. The glass lining is, however, costly and it therefore seemed worth while in conjunction with the foregoing trials to try to cover the concrete and render it non-porous in a cheaper way.

Some small cube-shaped containers were made of a mixture of one part of cement, two parts of sand and 5% of " Pudlo." The containers had an open top and a capacity of just over one gallon. These concrete vessels were treated in several ways ; after a good many experiments it was found that a mixture of 85 parts of paraffin wax and 15 parts of resin, melted together and applied hot to the inner surface of the container, gave a good covering and penetrated sufficiently into the pores of the cement to make it a lasting and effective coat. The hot mixture had to be applied twice to give a sufficient effect.

Two vessels treated in this way were filled as completely as possible with cider and covered with a glass-plate sealed down with wax. The cider (specific gravity 1.020, malic acid .65%, tannin .20%) was kept in these containers for nearly a year and compared with

the same cider kept in bottles. By the comparison it was found that the cider did not differ materially from the bottled control. There was no earthy or metallic flavour, as is the case to a very high degree with cider kept in uncoated cement containers. The only difference was that the cider in the cement vessels had fermented down to a specific gravity of 1.008, whereas the cider in the bottles had a specific gravity of 1.014. This was probably due to the fact that the sealing of the concrete vessel was forced open several times by the gas pressure and had to be remade. Thereby some access of air took place and fermentation was stimulated.

The season's results therefore suggest that it may be practicable to construct concrete tanks of suitable size treated with the resin-wax mixture which will be relatively cheap and serve as efficient substitutes for the expensive glass-lined cement vessels. Larger-scale trials are being proceeded with. On the other hand the respective cask treatments tested gave little promise of ultimate success in that direction.

THE INFLUENCE OF DIFFERENT SALTS AND ACIDS UPON THE GROWTH OF THE CIDER SICKNESS BACILLUS.

By Otto Grove.

It has been shown in previous work at Long Ashton that acids have a preventive influence upon the growth of the cider-sickness bacillus and it has been supposed in some quarters that exceptionally low contents of mineral salts in the cider favoured the development of the organism. A series of experiments has therefore been made to determine the toxic strength of various acids and salts significant for the cider industry.

The nutritive medium used for this experiment was yeast-water (prepared by boiling press-yeast with water) plus 5 per cent glucose. In this preparation the bacillus grows with great vigour. The medium was added the different salts and acids in varying proportions as indicated in the table below, inoculated heavily with a culture of the bacillus, and the culture flasks were placed at 25° C. and kept under observation for six weeks. If no development of the bacillus took place within six weeks, it was concluded that growth was prevented by the addition of the respective substance. As a rule, when growth took place, it developed in 3-5 days.

The + sign in the table indicates growth, the — sign indicates no growth.

Percentage added.	·02	·03	·04	·05	·06	·07	·08	·09	·1	·2	·3	·4	·5	·6	·7	·8	·9	1
Potassium tartrate	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Potassium chloride	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Potassium sulphate	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Sodium chloride ..	+	+	+	+	+	+	+	+	+	+	+	+	+	+	—	—	—	—
Sodium sulphate ..	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Sodium benzoate ..	+	+	+	+	+	+	+	+	+	+	+	+	—	—	—	—	—	—
Calcium sulphate ..	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Calcium chloride ..	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Magnesium chloride	+	+	+	+	+	+	+	+	+	+	—	—	—	—	—	—	—	—
Citric acid ..	+	+	+	+	+	+	+	+	+	+	+	+	—	—	—	—	—	—
Malic acid ..	+	+	+	+	+	+	+	+	+	+	+	+	—	—	—	—	—	—
Tartaric acid ..	+	+	+	+	+	+	+	+	+	+	—	—	—	—	—	—	—	—
Phosphoric acid ..	+	+	+	+	+	+	+	+	+	+	+	—	—	—	—	—	—	—
Sulphuric acid ..	+	+	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Boric acid ..	+	+	+	+	+	+	+	+	+	+	+	—	—	—	—	—	—	—
Salicylic acid ..	+	+	+	+	+	—	—	—	—	—	—	—	—	—	—	—	—	—
Lactic acid ..	+	+	+	+	+	+	+	+	+	+	+	+	—	—	—	—	—	—

It will be noted that the salts in the table have no deterrent action in the quantities dealt with here, with the exception of magnesium chloride, of which an addition of .3% prevents growth, sodium benzoate, of which .5% is necessary and sodium chloride, in the case of which .7% has to be added to stop growth.

As regards acids, of those of natural occurence in fruit tartaric acid seems to be most effective, .3% being required to prevent growth, whereas .5% of citric, malic, and lactic acid is necessary to produce the same effect. Sulphuric acid has a strong action, an addition of .05% completely stopping growth. Salicylic acid was fatal when .07% was added and boric acid when the liquid contained .4%.

Some combinations of salts and organic acid were tried and it was found that .3% malic acid in combination with .2% sodium chloride and .2% tartaric in combination with .2% sodium chloride prevented growth.

An addition of 6.5% by weight of alcohol was found to be necessary to prevent the development of the bacillus.

CIDER-MAKING TRIALS FOR THE SEASON 1922-1923.

By Otto Grove.

The 1922 crop of vintage apples was more distinguished by quantity than quality. In nearly all districts the crops were very heavy, but from the cidermaker's point of view the apples were not very satisfactory. The juices were thin with a low sugar content, the average specific gravity of all the juices being only 1.047, which compares unfavourably with the average of 1.060 obtained with the 1921 juices. This fact was probably due to the cold and wet spring and summer, the apples not being able to get sufficient sunshine to mature properly. The low specific gravity of the juices had naturally a pronounced influence upon the resulting ciders, which in many cases lacked body and fullness of flavour.

In the tables appended will be found a list of 55 ciders and perries made during the season from separate varieties of apples and pears. Besides these a number of lots of mixed apples from different districts were made up, keeving, racking and other experiments being carried out with them.

In some of the latter a method of removing the fermentation organisms by settlement was tried. It consisted in racking the cider into flat square wooden vessels, where it was allowed to settle for varying lengths of time. The cider was then drawn from the yeast-deposit into a similar vessel, where it was left to deposit again for 24 or 48 hours and then racked into a cask. By this method it was possible in some cases to check the fermentation to a certain extent as compared with ordinary racking, but the results were not conclusive, and the method will be tried again this season. Upon the whole the racking and keeving experiments carried out did not give very encouraging results and it was in many cases found to be impossible by those methods to check fermentation sufficiently to retain as much sweetness in the cider as is generally desired by the public. In most cases a dry cider was the result. As is well known, juices behave very differently as regards rates of fermentation, and the thin and fairly quick fermenting juices typical of the season did not lend themselves well to treatment by racking with the object of producing a sweet cider.

Experiments are in hand with a filter of a simpler and cheaper construction than those at present on the market. It is hoped that

they will lead to the construction of an efficient filter, the price of which would not be prohibitive for the farmer or the small cider-maker.

Several ciders from culinary varieties were made. The Bramley's Seedling cider was made very late (February 26th) from a lot of small apples sent in for trial. The apples were not at their best and the resulting cider was rather thin and without much flavour. The Worcester Pearmain juice was distributed in five casks, of which one was filtered when the specific gravity after 12 days had fallen to 1.025, another cask when the specific gravity had fallen to 1.020, the third cask at 1.015, the fourth at 1.010 and the fifth cask was racked and not filtered. When the samples were compared after about six months the first filtered sample was a very good cider of pleasant flavour with the particular aroma of the apple well marked, the second was not quite so good, although fairly pleasant, the two last filtered were rather thin and insipid, and the unfiltered sample was not clear and inferior to the rest of them. All the Worcester Pearmain ciders lost somewhat in quality during longer keeping. Lane's Prince Albert and Warner's King produced fairly pleasant ciders of the sharp type, which lend themselves well to blending with sweet and bitter-sweet varieties. A number of blends of ciders made from culinary varieties with ordinary ciders were made up as stated in the following table and tested for quality on the occasion of the Annual Tasting day. They were judged to be good ciders, similar in flavour and aroma to the best ciders made from mixed apples.

Of the sharp varieties on the list, No. 1, Lambrook Pippin, was a fine cider with excellent flavour. This apple deserves to be cultivated more extensively, as it is a good grower and cropper, keeps remarkably well and produces generally a slow fermenting juice. Spice apple gave a very useful sharp cider, and Crimson King was acceptable although thin. Tom Putt and Goose Apple were both very fair, but the first named lost in flavour during the summer. Frederick was not quite so good as usual for this excellent variety. The Foxwhelps were very fair, the best sample being No. 11, which was a good representative of the type. Cap of Liberty, No. 13, was a very good cider, but the typical flavour was not so pronounced as it is in better vintage years. Nine samples of Kingston Black were made up; of these Nos. 15, 17, 19, and 21 were judged the best and were fairly good types of this well known variety. In the case of No. 22 some of the juice had been pasteurised at 70° C. and was fermented with the following pure yeast types :— No. 4 (isolated from a Frederick cider), and No. 6 (isolated from a Kingston Black cider). They were both judged to be a little cleaner in flavour than the control fermented in the ordinary way, No. 6 giving the best result.

No.	Name of Variety.	District where Grown.	Date of Making.	Specific Gravity of Fresh Juice.	Malic Acid per cent.	Tannin per cent.	Rate of fermentation at 25°C.	Date of Filtering	Specific Gravity May, 1923.
	APPLES—								
	SHARP VARIETIES—								
1	Lambrook Pippin ..	.. Martock, Som. ..	15th December	1·042	0·54	0·20	4·0	9/1/23	1·024
2	Spice Apple .. .	.. North Cadbury, Som.	15th December	1·042	0·63	0·17	3·0	2/1/23	1·025
3	Crimson King	.. Chard, Som. ..	21st November	1·044	0·64	0·17	4·1	21/12/22	1·025
4	Tom Putt	.. Ledbury. Her. ..	16th November	1·048	0·68	0·15	6·0	6/12/22	1·030
5	Goose Apple	.. Hereford	11th November	1·045	0·60	0·17	3·3	15/12/22	1·030
6	Frederick	.. Monmouth	30th November	1·047	0·68	0·11	4·1	22/12/22	1·030
7	Foxwhelp	.. Nunnington, Her. ..	23rd November	1·061	1·05	0·33	5·8	1/1/23	1·028
8	,, ...	.. Withington, Her. ..	26th October	1·054	0·66	0·28	6·6	4/12/22	1·031
9	,, ...	.. Yatton, Som. ..	21st November	1·050	0·93	0·28	3·2	28/12/22	1·033
10	,, ...	.. Credenhill, Her. ..	10th November	1·054	0·93	0·31	3·8	12/12/22	1·034
11	,, ...	.. Ledbury. Her. ..	15th November	1·060	1·12	0·36	3·7	28/12/22	1·034
12	Cap of Liberty ..	.. Martock, Som. ..	15th Decembe	1·049	0·86	0·22	2·3	4/1/23	1·025
13	,, ,, ..	.. ,, ,, ..	23rd November	1·051	0·95	0·21	3·0	15/12/23	1·034
14	Kingston Black ..	.. Credenhill, Her. ..	20th November	1·054	0·63	0·19	2·7	20/1/23	1·024
15	,, ,, ..	.. Kingsweston, Som...	20th November	1·057	0·61	0·21	3·8	6/1/23	1·026
16	,, ,, ..	.. Spetchley, Wor. ..	17th November	1·057	0·59	0·22	3·1	22/1/23	1·027
17	,, ,, ..	.. Withington, Her. ..	28th November	1·050	0·59	0·18	3·0	18/1/23	1·027
18	,, ,, ..	.. Moorhampton, Her.	16th November	1·054	0·51	0·20	3·3	24/1/23	1·028
19	,, ,, ..	.. Hele, Devon ..	20th November	1·055	0·52	0·19	2·5	3/2/23	1·028
20	,, ,, ..	.. Congresbury, Som.	2nd November	1·063	0·75	0·26	4·8	30/12/22	1·029
21	,, ,, ..	.. Ledbury, Her. ..	20th November	1·055	0·63	0·20	3·1	3/2/23	1·036
12	,, ,, ..	.. Hereford	20th December	1·061	0·59	0·19	2·6	26/2/23	1·025
23	,, ,, ..	.. ,, ...	20th December	1·061	0·59	0·19	2·6	12/3/23	1·028
	SWEET VARIETIES.								
24	Sweet Alford	.. Long Ashton, Som.	24th October	1·045	0·28	0·13	5·0	20/11/22	1·015
25	,, ,, ...	.. Newton Abbot, Dev.	30th November	1·050	0·20	0·13	2·8	18/1/23	1·022

26	Eggleton Styre	.. Long Ashton, Som.	7th November	1·048	0·38	0·11	6·5	28/11/22	1·018
27	,, ,, ...	.. ,, ,, ..	7th November	1·051	0·25	0·12	5·7	4/12/22	1·018
28	,, ,, ..	.. Ledbury, Her. ..	13th December	1·065	0·36	0·20	4·6	25/1/23	1·020
29	Dymock Red	.. Lydney, Glos. ..	20th December	1·042	0·33	0·11	3·8	16/1/23	1·018
30	Thomas Hunt ..	.. North Cadbury, Som.	12th December	1·056	0·23	0·16	3·8	2/1/23	1·019
31	Slack-ma-Girdle ..	.. Newton Abbot, Dev.	30th November	1·044	0·18	0·11	3·1	16/1/23	1·021
	BITTERSWEET VARIETIES—								
32	Royal Wilding ..	.. Byford, Her. ..	27th November	1·047	0·26	0·23	5·0	13/1/23	1·018
33	Cherry Norman ..	.. Long Ashton, Som.	25th November	1·043	0·28	0·26	3·0	28/12/22	1·022
34	Knotted Kernel ..	.. ,, ...	21st November	1·049	0·34	0·24	5·6	15/12/22	1·022
35	,, ,, ..	.. Byford, Her. ..	30th November	1·049	0·28	0·27	4·1	15/1/23	1·023
36	Chisel Jersey	.. North Cadbury, Som.	16th November	1·062	0·26	0·52	5·6	1/2/23	1·022
37	Yarlington Mill ..	.. ,, ,, ,,	4th December	1·050	0·24	0·33	5·2	17/1/23	1·023
38	American Norman ..	.. Moorhampton, Her.	11th November	1·045	0·28	0·34	4·0	22/1/23	1·025
39	White Norman ..	.. Withington, Her. ..	26th October	1·051	0·20	0·39	4·2	27/12/22	1·028
40	Royal George ..	.. Easton-in-Gordano, Som.	12th October	1·050	0·23	0·23	5·2	23/12/22	1·034
	CULINARY VARIETIES—								
41	Bramley's Seedling ..	.. Hereford	26th February	1·038	0·66	0·08	9·0	12/3/23	1·014
42	Worcester Pearmain ..	.. Chelmsford	22nd September	1·040	0·26	0·10	14·0	3/10/22	1·020
43	Lane's Prince Albert ..	.. Ross, Her.	8th December	1·042	0·69	0·10	8·3	19/12/22	1·025
44	Warner's King ..	.. Churchill, Som. ..	12th October	1·042	0·98	0·09	9·5	19/10/22	1·030

BLENDS OF CULINARY VARIETIES WITH CIDER VARIETIES.

45 Worcester Pearmain (2 parts), Kingston Black (1 part).
46 Worcester Pearmain (4 parts), Foxwhelp (1 part).
47 Newton Wonder (2 parts), Chisel Jersey (1 part), Kingston Black (1 part).
48 Bramley's Seedling (3 parts), Sweet Alford (2 parts), Kingston Black (1 part).
49 Lane's Prince Albert (4 parts), Worcester Pearmain (3 parts), Knotted Kernel (3 parts).
50 Warner's King (1 part), Worcester Pearmain (3 parts), Chisel Jersey (2 parts).
51 Crimson King (2 parts), Knotted Kernel (1 part)

No.	Name of Variety	District where Grown.	Date of Making.	Specific Gravity of Fresh Juice.	Malic Acid per cent.	Tannin per cent.	Rate of fermentation at 25°C.	Date of Filtering	Specific Gravity.
	MIXED APPLES.								
52	Mixed Apples—Cap of Liberty Sweet Alford, Strawberry Norman, Skyrme's Kernel and Foxwhelp.	Tibberton Trial Orchard	.. 4th December	1·050	0·66	0·21	3·6	4/1/23	1·023
53	Mixed Apples—Kingston Black Ecarlatine, Skyrme's Kernel. Royal Wilding, Cummy Norman and Sweet Alford.	Hardwick Trial Orchard	.. 20th November	1·048	0·37	0·17	3·0	15/1/23	1·022
	PEARS—								
54	Butt	Norton, Glos.	.. 25th October	1·053	0·48	0·09	4·6	23/1/23	1·025
55	Oldfield	„ „	.. 26th October	1·055	0·50	0·07	5·0	23/1/23	1·028

Of the sweet varieties No. 25 was a fair sample of the Sweet Alford type. Nos. 26 and 27 from the cider orchard at the Institute were made from a row of trees, of which half are in the grass part of the orchard, the other half in the cultivated part. The juice made from the apples from the cultivated part had the higher specific gravity, but the ciders did not otherwise show any appreciable difference. The other sweet varieties were not of special merit, the best being Nos. 28 and 31, which were both very fair specimens.

The bittersweet varieties had nearly all been tried before on several occasions and were fairly good samples. Two of them, viz., No. 38, called American Norman locally, and No. 40, Royal George, have not been tried previously; both of them gave fairly good ciders, the last mentioned being the more full bodied of the two.

Two lots of mixed apples from two of the trial orchards were made up and both of them produced good ciders; No. 52 from the orchard at Tibberton was the better, a full bodied cider with a well balanced flavour.

The two perries were somewhat flavourless when first made, but developed into very good perries after some months keeping and have kept their qualities well after about one year in bottle.

COLD-PROCESS FRUIT PRESERVES.

By B. T. P. Barker and Otto Grove.

Some experiments have been carried out to investigate the possibility of making preserves of fruits (jams, jellies and fruit-juices) without the application of heat. When such preserves are made in the usual way, they are, during their preparation, exposed to high temperatures for varying lengths of time, to the great detriment of their flavour and aroma and, frequently, of their colour. It was recognised that if it were possible to make similar preserves without using high temperatures, the volatile aromatic bodies, contributing largely to the flavour of the product and lost during the heating, would be retained and the preserve would possess the same delicious flavour as the fresh fruit. Also from another point of view an advantage would be gained, viz., that of the preservation of the so-called accessory food factors (vitamines), which are largely destroyed by heat. It has now been established that the great dietic value of fresh fruit depends not alone upon the sugars, salts and acids contained in the fruit but also upon the content of these substances, which are present in very minute quantities.

At the outset it must be emphasized that the keeping of such preserves prepared in the cold presents some difficulties in comparison with preserves made in the usual way, where the micro-organisms present in the fruit and other sources of infection and capable of causing deterioration of the product, are killed by heat. In the case of a jam or jelly made by the " cold " method, the constituency of the product must be made such that these micro-organisms do not develop. This can be done either by increasing the sugar content or by adding preservatives. Obviously the first method is preferable ; the object is, therefore, to aim at such a concentration that the micro-organisms present will not develop. This is generally the case when the percentage of sugar is 62—65, or lower if the acidity of the fruit is high.

These experiments have been essentially of a preliminary character and will be continued when soft fruit is again available.

Several methods have been tried, *e.g.*, (a) mixing the fruit with the necessary sugar, (b) mixing the expressed juice with sugar or sugar syrup to make a jelly, and (c) expressing the juice, boiling the press-residue with water and mixing the filtered extract when cold with the juice before adding the sugar.

"*Cold-process Jams.*"

A number of these preparations have been made, the general procedure being to crush the fruit and mix it as intimately as possible with sugar. The difficulty is to get the fruit pulp to take up sufficient sugar. Different sugars have been tried, also different preparations of amorphous sugar, but it has not yet been possible to get the sugar satisfactorily dissolved. The jams after some time in most cases separated into two layers, with the fruit pulp at the top and the juice at the bottom. Very often slight fermenta ion took place They were kept at room-temp rature for six months in ordinary jam-jars covered with paper.

Raspberries, strawberries, black currants, red currants, plums and gooseberries were tried. The amount of sugar varied, but generally about three parts of suger to two parts of fruit were used. The best results were obtained with gooseberries, where the jam formed a soft gel.

"*Cold-process Jellies.*"

The preliminary results obtained were much more satisfactory than with the jams. In this case only the freshly expressed juice was used : it was mixed with either cane sugar, sugar syrup, invert sugar syrup or combinations. The sugar syrup used was made with cane sugar, of which it contained 67—68%. The invert sugar was made by boiling cane sugar with 0.1% tartaric acid and water : it contained about 75% of invert sugar. In some cases there was also added an extract made by boiling the press residue with a little water, pressing again and cooling.

The juices of red and black currants were made with cane sugar, sugar syrup, invert sugar and press residue extract in varying proportions. The jellies were put into ordinary glass-jars and kept under observation for at least six months at room temperature. Several were failures owing to inadequacy of "gel," or deficient keeping quality, or both. It was found that the samples made with sugar syrup kept better than samples made with sugar. The following samples gave the most promising results :—

Red currant juice	100	parts by weight		Fair gel, flavour as fresh fruit, colour good. Slightly cloudy at top of jar, otherwise clear.
Sugar Syrup ..	200	,,	,,	
Red currant juice	100	,,	,,	Slight gel, good flavour and colour.
Sugar Syrup ..	100	,,	,,	
Invert sugar syrup	100	,,	,,	
Black currant juice	50	,,	,,	Fairly good gel, flavour excellent.
Sugar syrup ..	125	,,	,,	
Black currant juice	50	,,	,,	Good gel, flavour very good.
Sugar syrup ..	150	,,	,,	
Black currant juice	50	,,	,,	Good gel, good flavour, colour pale.
Sugar syrup ..	100	,,	,,	
Invert sugar syrup	50	,,	,,	

"*Cold-process Fruit Juices.*"

The ordinary fruit juices, used extensively in France and the south of Europe diluted with water as a summer drink, and in Germany and the north of Europe also made into fruit soups with barley, sago or other cereals, are prepared by boiling the juices expressed from the fresh fruit with sugar. Their flavour, as with jams and jellies, is very detrimentally affected by the high temperature and does not compare with the flavour of juices made by the "cold process."

The juices prepared at Long Ashton without the application of heat were made from loganberries, raspberries, black currants and blackberries.

After trying several methods the following mode of preparation, which has upon the whole given satisfactory results, was adopted. The berries were well broken up and placed in an open vessel in a fairly warm place for a period varying from 4 to 5 days. Within that time there was slight fermentation, the pectin substances being precipitated and the gelling of the juice after the addition of sugar thereby prevented. In the case of blackberries it was found necessary to add a little sugar or, better, 10—20% of fresh apple juice, to get a satisfactory fermentation and precipitation of the pectins. After the fermentation the whole was pressed and the expressed juice mixed with sugar and put into a closed container, which was shaken up every day for a couple of weeks, more sugar being gradually added so that there was always undissolved sugar present. The object was to obtain a saturated solution of sugar in the juice. The juice was then filtered through flannel and put into closed bottles, which were only partially filled to make the keeping test more severe.

The juices have been stored in this way for over two years and have kept very well. There has been no fermentation and only in some cases a little sugar has deposited in the flasks. The colour and flavour is very good. The percentage of sugar present in the juices varies from 62.5 to 64.5.

This preliminary work has shown the possibility of the production of cold-process fruit juices and jellies of high quality in respect of flavour, appearance and keeping properties. Whether or not the methods are suitable for development under commercial conditions larger-scale trials, which it is proposed to carry out at the Campden Research Station, will demonstrate.

NOTES ON STRAWBERRY BREEDING.

By G. T. Spinks.

The work on the breeding of strawberries, to which reference has been made in previous Reports, has now reached a stage at which it seems desirable to give some account of the results which have already been obtained. This work must be regarded largely as a preliminary to further breeding in which the experience already gained can be utilised. The object of the breeding work is the production of new varieties which will be superior to the old ones, and in the hope of finding out what combinations of parents are likely to lead to this result most quickly a large number of different crosses have been made, though only comparatively small numbers of plants of each family have been raised. Having now gained some of this preliminary information larger numbers of the most promising families will be raised, and it may then be possible to discover more of the genetics of various characters.

When making a cross one particular character was usually aimed at, though the parents used always had other desirable qualities in addition, and therefore at the present stage it seems best to state the results under the headings of the various characters. It should be noted that the following figures were usually obtained from observation of single plants for not more than two years, but in some cases plants have been propagated by runners, and observations have therefore been obtained from larger numbers of plants for several years.

Crop.

The fruitfulness of a plant is one of the most important characters to be considered, for unless a variety bears heavy crops it is almost useless, at all events from a commercial point of view. The size of the crop of single plants has been estimated by eye, but where larger numbers of plants have been available a certain number of records of crop weights have been taken.

Crops have been arbitrarily classified as poor, moderate, fairly good and good, the last classification indicating a really heavy crop, though in a few cases the crop has been thought to merit the description very good.

No seedlings whose crop was not at least fairly good have been considered worthy of further trial.

Some of the most interesting observations made on the fruitfulness of different families of seedlings are as follows :—

Bedford Champion × *King George V.* (Laxton). Out of a family of 235 seedlings, 57 were noted as fairly good croppers and 25 as good, while 57 were poor. Both the parents are good croppers.

King George × *Black Prince.* A small family of 20 plants, but of these seven bore fairly good and six good crops.

Scarlet Queen × *King George.* A family of 179 contained 45 plants with fairly good crops, and 14 with good crops, while 32 were only poor croppers.

The Duke × *White Perpetual.* A very small family, only 20 plants, but of these nine bore good crops.

La Productive × *Keen's Seedling.* Out of 63 plants, 27 were fairly good croppers and six good.

Royal Sovereign × *Keen's Seedling.* A small family of 22, but these included 10 fairly good and two good croppers.

Maincrop × *Laxton.* Sixty-two plants included 27 with fairly good and 14 with good crops.

Maincrop × *Royal Sovereign.* A family of 35 gave 15 fairly good and seven good croppers.

The Earl × *Unique.* Twenty-five fairly good and eight good croppers were obtained from a family of 71.

St. Antoine × *The Earl.* A family of 38 contained 11 plants with fairly good and five with good crops.

The above list includes the families which, up to the present, have given the largest proportion of heavy-cropping plants. Other families which have given slightly less satisfactory results are :—*King George* × *The Duke*, *King George* × *White Perpetual*, *Vicomtesse* × *The Earl*, *Fillbasket* × *Bedford Champion*, *Vicomtesse* × *King George*, *King George* × *St. Antoine.*

Families which have given disappointing results considering the cropping powers of their parents are :—*Bedford Champion* × *Maincrop* and the recriprocal cross, *Cropper* × *Vicomtesse*, and the recriprocal cross, and *Royal Sovereign* × *King George.* The last-named cross gave 46 poor croppers and only eight fairly good croppers out of a family of 114. The poor records of some of these families cannot always be considered conclusive, as in some cases a family has possibly been planted on a bad strip of soil. Good croppers have also been obtained from families not named above, but they do not form a large proportion of their families. *Bedford Champion*, *Keen's Seedling*, *King George*, *Maincrop*, *Royal Sovereign*, *The Earl*, *The Duke* and *Vicomtesse* have all been found satisfactory parents to use when breeding for crop, though their progeny do not necessarily always include a large proportion of good croppers.

Earliness.

Earliness in ripening being a very valuable quality in a strawberry, many crosses have been made with the object of producing early varieties. When a cross is made between two early varieties it has been found that a large proportion of the resulting seedlings are of second early season, while there are also varying numbers of early and maincrop plants and occasionally a very few late varieties. An early variety crossed with a perpetual fruiter appears to give much the same result as the above, while if one of the parents is an early and the other a second early or a maincrop variety the majority of the seedlings usually tend more towards the maincrop season and there are fewer earlies though still a fair number of second earlies.

Occasionally, however, a cross in which one of the parents is a maincrop variety gives an unexpectedly large proportion of early seedlings.

The crosses which have given the largest proportion of early seedlings are as follows :—

King George × *Black Prince.* A small family of 20 plants, but of these 10 are earlies.

King George × *The Duke.* Also a small family ; 16 plants, of which six are earlies.

Maincrop × *Royal Sovereign.* A maincrop variety crossed with an early, but a family of 35 plants contains 12 earlies.

Maincrop × *The Laxton.* Here again one parent is a maincrop variety, but in the family of 62 there are 10 early plants.

Vicomtesse × *King George.* Twelve early plants in a family of 61.

The Bedford × *Keen's Seedling.* A cross between a maincrop and a second early ; the family of 57 contains 11 early seedlings.

The Duke × *White Perpetual.* A small family of 20 plants includes five earlies.

The Earl × *Unique.* Sixteen early seedlings out of a family of 71.

Many other families besides those mentioned above contain a number of early plants, though not so large a proportion, and the fact that a family contains only a small proportion of early plants does not necessarily mean that some of the individuals are not as early as, or earlier than, the individuals in a family containing a larger number of early plants.

Whether any of these early plants which may have been selected for propagation are actually earlier than any varieties now in use, can only be decided after they have been tried for several years.

Lateness.

The extension of the strawberry season by the production of good late varieties has also been kept in view and a number of

crosses have been made with this object. A late variety crossed with another late variety, a maincrop variety, or a perpetual fruiter, has been found to produce a preponderance of maincrop plants, together with a varying proportion of late seedlings and sometimes a few second-earlies.

The largest proportion of late seedlings has been produced in the following families :—

Laxton's Latest × *The Earl.* Out of 152 plants 22, or possibly more, are late in season.

St. Antoine × *The Earl.* Nine plants out of 38 are late.

Madame Kooi × *Doctor Hogg.* A family of 162 includes 15 or more late seedlings.

Another cross which has given a fair proportion of late seedlings is : *Givon's Late* × *St. Antoine.* Where a late variety and an early one have been crossed the resulting families have consisted largely of maincrop plants, with smaller numbers of late plants and second-earlies. In the case of *Vicomtesse* × *The Earl,* the numbers in a family were approximately four earlies, seven second earlies, 35 maincrops, and 11 lates.

Size.

As it is obviously desirable that strawberries should be fairly large, most of the parents used in making crosses have been large-fruited forms, though smaller-fruited varieties have sometimes been used if they possessed some other good quality which it was desired to introduce into the cross. When two large-fruited parents were used a majority of the resulting seedlings usually bore moderate-sized fruit, quite a large proportion bore fruit of fair or large size, and only a small proportion bore small fruit. If one of the parents bore only moderate or small fruit a smaller proportion of the seedlings bore fruit of fair or good size and a larger proportion bore small fruit.

The size of the fruit has in every case been estimated by eye.

The largest proportion of large-fruited seedlings has occurred in the following families :—

Maincrop × *The Laxton.* Six large and 20 fairly large-fruited plants in a family of 62.

Bedford Champion × *King George.* In a family of 235 plants 37 bore large and 29 fairly large fruit.

Scarlet Queen × *King George.* Out of 179 plants 15 bore large and 13 fairly large fruit.

Laxton's Latest × *The Earl.* Eleven large and 15 fairly large-fruited plants out of 152.

Other families which gave a fair proportion of large-fruited plants were : *Maincrop* × *Royal Sovereign*, *President* × *St. Antoine*, *Reliance* × *Maincrop*, *Bedford Champion* × *Maincrop* and *Madame Kooi* × *Doctor Hogg*.

Colour.

Observations on the inheritance of colour in the fruit are at present very incomplete, but the information obtained so far points to the following conclusions : A dark crimson fruit crossed with another dark fruit produces either all dark fruits or many dark fruits and a smaller number of lighter coloured fruits. A cross between a dark and a scarlet fruit results in the production of both dark and scarlet fruits by the seedlings (in approximately equal numbers ?) ; while a dark fruit crossed with a pale pink fruit produces scarlet and pale fruits.

A cross in which both parents are scarlet usually produces dark, scarlet and a few pale fruits, and a scarlet fruit crossed with a pale fruit leads to both scarlet and pale fruits, possibly in about equal numbers. The seedlings from a cross, where both parents have white or very pale pink fruit, all seem to bear similarly pale fruit, and the same result is obtained by self-fertilising a pale-fruited plant, such as White Perpetual. As all gradations of colour from white to a very dark crimson occur in different varieties it is almost impossible to classify the fruits in three or four definite colours. Some scarlet-fruited varieties, when used as parents, seem more disposed than others to throw pale-fruited seedlings ; such seems to be the case with King George.

Shape.

The shape of the fruit is another rather difficult character to classify, as there are so many intermediates between any fairly definite shapes, such as round, conical, and wedge or coxcomb, which may be chosen. Detailed observations on the shape of the fruits of seedlings have not been made, and usually only a general impression of the fruits of each family has been obtained. Such a general impression leads one to think that the round and conical shapes are in a great measure dominant to the wedge or coxcomb form.

Texture.

In selecting seedlings for further trial much attention is paid to the texture, or in other words the firmness and " carrying " properties, of the berries. No method has yet been employed for judging this except the touch of the fingers. No record has been obtained of the texture of very many of the seedlings, as owing to the limitations of time it has usually only been possible to make observations on those plants which have other qualities which

make them worthy of special attention. The only conclusion which can be drawn from the results at present is that a soft-fruited variety, such as White Perpetual, The Queen, or Louis Gauthier, when used as a parent, gives rise to seedlings which all, or nearly all, bear soft fruit. Parents with fruit of moderate texture produce plants with fruit of all degrees of firmness, and this also seems to be the case when firm-fruited parents are used. It has not yet been found that a family of plants from two firm-fruited parents gives a very high proportion of firm fruits. Perhaps the largest proportion of firm fruits yet found have been on the plants from the cross *Maincrop* × *Royal Sovereign.*

Flavour.

This is another character on which comparatively few notes have been made, owing to the fact that during the short time the plants are fruiting it is impossible for one man to taste the fruit from such a large number of plants. Observations on flavour have, therefore, been confined largely to those plants which seem promising in other respects. Possibly in the future detailed notes may be made on the flavour of the fruit from each plant in one or two large families raised for the purpose of finding out something about the inheritance of flavour.

As other breeders of strawberries have noted, the flavour of the fruit of seedlings is very variable, in many cases it is peculiar, and in some cases it is actually unpleasant. Almost every family of seedlings has been found to bear a large proportion of fruit of poor or moderate flavour, while a few plants in each family bear fruit with a good flavour. Very little difference in this respect between different families has yet been detected, but perhaps the largest proportion of good-flavoured fruit has been found in the progeny of *Bedford Champion* × *King George*, *Leader* × *St. Antoine*, and *Fillbasket* × *Bedford Champion.* No general rule indicating the inheritance of such qualities as acidity or sweetness had yet been found. It has, however, been found that the fruits of a large proportion of the seedlings from *The Queen*, *Louis Gauthier*, and *White Perpetual* have a rather sweet, scented, and watery flavour, lacking in acidity. This type of flavour seems to be associated with a fruit which is soft and pale in colour.

Foliage.

It has not yet been found possible to trace definitely the connection between the type of foliage of a family of seedlings and that of their parents, nor has any correlation been found between the type of foliage and the type of fruit, but further notes on these points will be taken. Considering only the number and size of leaves, there are found in each family plants which are distinctly

leafy and others which have various smaller quantities of foliage; but as the amount of foliage depends on the general health of the plant too much stress must not be laid on this point, especially as most of the observations so far have been made on only one plant of each seedling variety. There are, however, certain families which are, on the whole, distinctly more leafy than the average, *e.g.*, *The Bedford* × *Keen's Seedling*, *King George* × *Black Prince*, *La Productive* × *Keen's Seedling*, *President* × *Keen's Seedling*, *President* × *St. Antoine*, *Royal Sovereign* × *Keen's Seedling*, *Vicomtesse* × *King George*, *Louis Gauthier* × *Keen's Seedling*. It will be noticed that *Keen's Seedling* is one of the parents in a number of these cases. Very occasionally one of the most leafy plants has been found to be blind, but usually the crops are as good on a very leafy plant as on any other. Possibly, however, extreme leafiness may be detrimental to the crop through shading the fruit and encouraging mildew.

Vigour.

As single seedling plants have mainly been under observation so far, and as a single plant may so easily be damaged by some insect or other external agency which may be overlooked, too much emphasis must not be placed on the vigour of the seedlings. Also, as has already been mentioned, the seedlings have not been grown on ground which is quite uniform, and it is suspected that the weakness shown by several complete families is due to soil influence rather than to their constitution. Further, the observations must be understood to apply to Long Ashton conditions of soil and climate, but the same results would not necessarily be obtained in other situations, as it is well known that different varieties of strawberries are definitely suited to different conditions. However, the following observations on vigour in the various families have been made. The families which on the whole were the most vigorous were: *Louis Gauthier* × *Keen's Seedling*, *Scarlet Queen* × *King George*, *Royal Sovereign* × *Keen's Seedling*, *President* × *St. Antoine*, *President* × *Keen's Seedling*, and *La Productive* × *Keen's Seedling*.

The following families consisted mainly of weak plants: *The Queen* × *Reliance*, *The Count* × *President*, *White Perpetual* selfed, *International* × *Laxtonian*, *British Queen* × *Sir J. Paxton*, *Maincrop* × *Bedford Champion*, *Louis Gauthier* × *White Perpetual*, *Reliance* × *Maincrop*.

Disease.

The only observations made on diseases up to date have been on the occurrence of mildew (*Sphaerotheca humuli*). No complete record has been kept of attacks of mildew, but every obviously badly mildewed plant was noted. A large proportion, one third to one half, of badly mildewed plants have been found in the following crosses: *Scarlet Queen* × *King George*, *King George* × *Black*